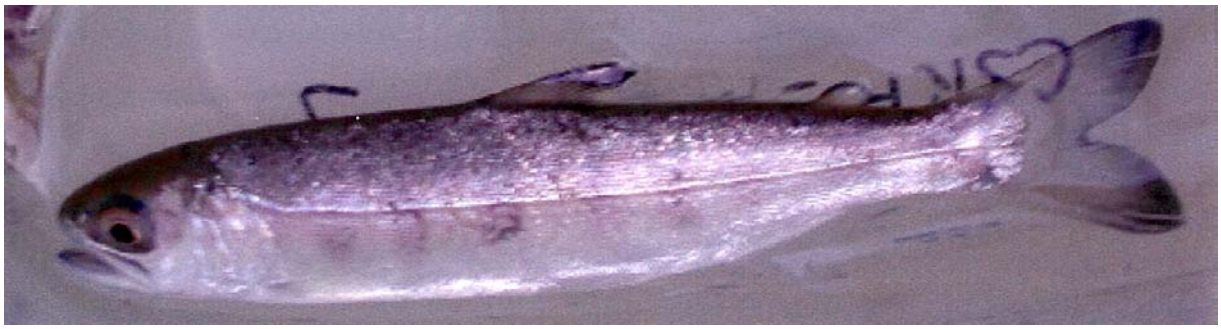
LONG-TERM COHO SALMON AND STEELHEAD MONITORING
PACIFIC STATES MARINE FISHERIES COMMISSION GRANT CAWIP-CR-37
FINAL REPORT

SPRING 2004 SMOLT TRAPPING & TRIBUTARY JUVENILE SURVEYS



PORE/NR/WR/04-04

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1.0 BACKGROUND AND OBJECTIVES

Smolt trapping is conducted in selected salmonid-bearing watersheds where the NPS is performing basinwide population estimates. This program requires intensive monitoring at just a few locations typically between March and June of each year.

1.1 Introduction and History

In 1997 the National Park Service (NPS) initiated the Coho Salmon and Steelhead Trout Restoration Project (CSRP) to assess watershed and fishery condition in Marin County, and develop recommendations to enhance local populations of these anadromous species. The project watersheds including Redwood Creek, Pine Gulch Creek, and tributaries of Lagunitas Creek (Olema Creek, Cheda Creek, and Devil's Gulch) are located in western Marin County, and within the National Marine Fisheries Service (NOAA-Fisheries) designated central California coast Evolutionarily Significant Unit (CCCESU). Anadromous fish populations throughout the state of California are estimated to be 1% of historic populations. Though dramatically reduced from the mid 1900s, the Lagunitas Creek watershed contains 10% of the remaining fish (Brown and Moyle 1991) and is considered the keystone population of the CCCESU.

Through this program, monitoring efforts, including adult escapement, smolt trapping, juvenile index reach, and basinwide population estimates have been conducted. This document reports the results of all smolt trapping operations conducted through the NPS monitoring efforts since 1998, including John West Fork of Olema Creek (1998-2004), Pine Gulch Creek (2001-2004), and lower Olema Creek (2004).

These monitoring efforts continue salmonid research initiated and conducted by the National Park Service - Coho Salmon and Steelhead Trout Restoration Project (CSRP) between 1997 and 2002. Since 2002, monitoring has been supported through a variety of programs, including NPS and non-federal funding. The work conducted under grant agreement CAWIP-CR-37 was matched by NPS fishery monitoring staff supported through the NPS Inventory and Monitoring Program.

The NPS has operated a smolt trap annually since 1998 on the John West Fork, an important tributary of Olema Creek at a site upstream of a culvert identified as a fish passage barrier, which was modified to improve passage in 1999. In 2004, PORE completed the seventh year of trap operation, including two years prior to fish passage restoration and five years since restoration. Monitoring at this site has yielded important information related to restoration, spring downstream movement of both smolts and fry, and productivity within an intermittent watershed. In 1999 the CSRP operated four other traps in addition to the John West Fork trap that showed the importance of tributaries to overall watershed smolt production. The 1999 traps were located on Giacomini Creek and Quarry Gulch (Olema Creek tributaries), Bear Valley Creek (Lagunitas Creek tributary), and Pine Gulch. The NPS has also operated a smolt trap on Pine Gulch annually since 2002, and began trapping on the mainstem of Olema Creek in spring 2004. The location of the 2004 monitoring sites is shown in Figure 1-1.

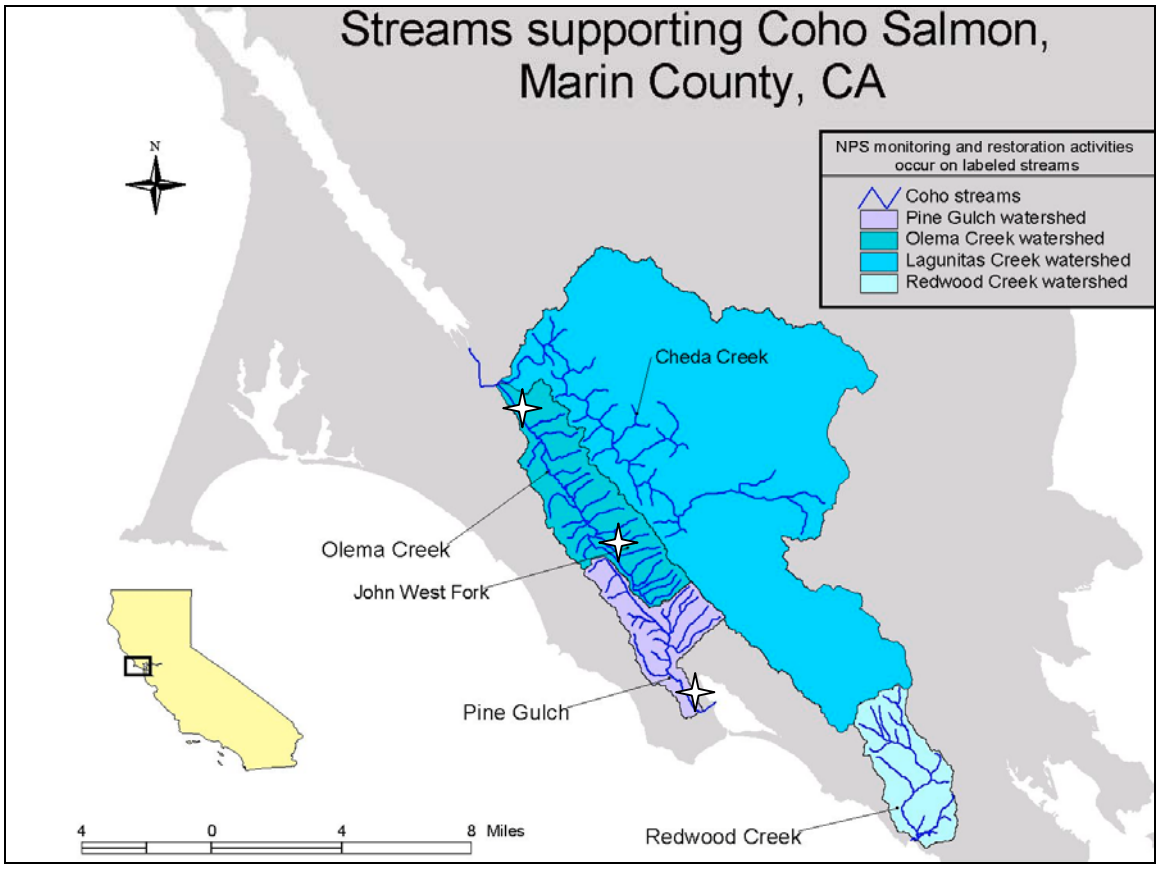

Figure 1-1 Locations of smolt traps monitored in 2004 on coastal Marin County, CA watersheds.

1.2 Rationale for spring outmigrant smolt trap program

Performed in conjunction with winter spawner surveys and summer juvenile surveys, the spring outmigrant surveys permit an evaluation of abundance during three of five distinct freshwater salmonid life history stages. A significant body of literature has documented life-stage bottlenecks and survival rates for salmonid populations. Many of these studies describe how alterations to watershed connectivity and condition affect these species at these different freshwater life stages. At the time they smolt, most coho have spent more than 14 months in the watershed, while steelhead can be 1-4 years old. Smolt production, therefore, is the best aggregate measure of watershed condition and productivity. The response of coho and steelhead populations to changes in habitat quality can not be properly assessed without a measure of smolt production.

When evaluated as part of a comprehensive monitoring program, the smolt trap information can be compared with adult spawner indices to describe potential ocean productivity and survival, and with summer juvenile population estimates to assess rates of survival through the winter season. This type of comprehensive monitoring information is rare in this region, as most of this research has been focused in the Pacific Northwest. The habitat and climate supporting salmonids in this area have not been well studied, meaning that local adaptations by these species are not well understood. Smolt trap monitoring, in conjunction with other life stage monitoring activities allows the NPS to characterize aggregate watershed productivity for salmonids, and is a valuable resource for directing long-term management and restoration actions. Although smolt trapping is focused on salmonids, it also provides additional presence and size measurement data for other aquatic species during periods not covered by summer/fall monitoring activities.

Aside from the large scale benefits associated with the trapping program, results from the John West Fork trap have allowed the program to quantify dates of fry emergence and rates of growth through the spring season. Through smolt trapping, the NPS has documented downstream movement of both smolts and fry in the spring season as flow in the intermittent watershed recedes. Our monitoring has documented anywhere from 1,000 to 6,000 salmonid fry heading downstream from the spawning grounds, towards more perennial flow and suitable summer habitat

Data collected through smolt trapping also has direct management utility. An understanding of the environmental factors and dates that result in cessation of downstream smolt movement may be used to determine instream construction windows that would not impair movement of smolts.

1.2.1 Monitoring Objectives

1. Estimate coho and steelhead smolt yields.
2. Determine length and weight characteristics of coho and steelhead smolt, presmolt, and parr.
3. Compare potential and observed stream carrying capacity.
4. Measure environmental factors thought to govern outmigration of fish.

1.2.2 Monitoring questions

1. What is the aggregate watershed productivity for coho salmon?
2. How does smolt productivity and condition relate to associated adult spawner counts for the year class?
3. What are estimated winter survival rates for juvenile salmonids within the west Marin County watersheds, as measured through comparison with summer surveys?
4. What is the ocean survival and return, as related to watershed smolt production?
5. Are measured environmental factors linked to patterns in downstream migration and are they consistent with scientific literature?
6. How does smolt condition compare between fish from perennial vs intermittent streams?

1.2.3 Other Monitoring Programs

There are no other local programs that incorporate smolt trap monitoring in coastal Marin County. Recent reporting associated with the Lagunitas Creek Limiting Factors Analysis identified outmigrant smolt

trapping as a priority monitoring effort that would contribute to overall understanding of the salmonid populations in Lagunitas Creek (Stillwater 2004).

1.3 Measurable Results and Deliverables

Smolt trap monitoring is an effective means, in conjunction with winter adult surveys, and summer juvenile population estimates, of measuring aggregate watershed condition for areas upstream of the trap. The NPS has also used this method to document response to discreet restoration activities, such as the restoration of fish passage through road culverts.

Within the John West Fork, monitoring has shown a dramatic response in smolt productivity in response to adult passage improvements through the State Route 1 culvert. The information that is being developed around the Pine Gulch Creek watershed shows how this information can be used to characterize overall watershed condition and survival through the winter season. In Pine Gulch, monitoring has shown that approximately 50% of the juveniles estimated in the summer surveys survive through the winter season. This is a significant rate of survival between these life stages, and indicates that availability of winter refugia is not a population bottleneck in this system.

Information produced through this program includes weekly and daily totals of fish captured, including smolts, other age 1+ juveniles, and young of year. Weight-length relationships for smolts and other age 1+coho salmon and steelhead may also be reported. Analysis of such data in 2002 showed distinct differences in the weight-length relationship between fish from Pine Gulch Creek and the John West Fork.

In addition, tissue and scale samples are collected from a subsample of fish moving through the smolt trap during each year. Collected samples are catalogued and submitted to the NOAA Fisheries Genetics Lab in Santa Cruz CA for analysis. This will allow for further genetic analysis of central California coast salmonids, as well as age-length relationships and determination of smolting age for both coho and steelhead.

2.0 METHODS

This smolt trapping program currently employs pipe-style downstream outmigrant traps at two locations within the NPS monitored watersheds: The John West Fork (monitored annually since 1998) and Pine Gulch (since 2002). The trapping is conducted continually for a 2-3 month period during the spring and requires daily checking by field staff. The pipe traps used by this program are based on methods developed in northern California for trapping small streams (Manning and Roelofs 1996; Manning 2001) and have proven effective for the current monitoring sites. They are designed to catch all fish moving downstream and effectively result in a census of smolt outmigration. Each pipe trap operates by impounding water behind a weir constructed of ½ inch mesh hardware cloth and t-posts that spans the entire width of the stream. Flow is directed into a series of 20 ft. long, 8 inch diameter PVC pipes. To decrease water velocity, the pipes empty onto a slanted, perforated metal ramp (McBain's ramp). The ramp is connected to a 125 x 74 x 50 cm box constructed of plywood and 1/8 inch mesh hardware cloth. The trap box contains a baffle to further slow water velocity, as well as a mesh divider screen and rocks and vegetation to provide cover and refugia for fry. The weir contains one or more notches or vents that allow adult steelhead to migrate upstream during higher flows.

In spring 2004, a fyke/pipe design was installed and operated successfully at the lower Olema Creek site. The fyke/pipe trap on the Olema mainstem is based on a design used by CDFG on the Noyo River (Gallagher 2000, 2002a; Barrineau and Gallagher 2001). A 5' x 20' fyke net is supported by t-posts and a frame consisting of 1" galvanized pipe. Several 4' x 8' weir panels, each consisting of a 2x4 frame and ½" mesh hardware cloth, are secured with t-posts and zip ties to direct fish into the mouth of the fyke net. A small gap is left between the weir panels and the streambank on one side to allow upmigrating steelhead to pass. The throat of the fyke net is attached to a series of 6" x 20' PVC pipes, which empty onto a McBain's ramp attached to a plywood trap box as described above.

Trap sites were determined by location within each watershed, suitable channel morphology, and access. The John West Fork trap site is located immediately above the State Route 1 culvert in order to assess fish passage success as reflected by yearly smolt production. It is approximately 200 m upstream of the mainstem confluence, so it also traps the majority of smolts emigrating from this tributary. In some years a second trap was placed 600 meters upstream of the main trap site, immediately above a denuded area that dries up in late spring, in order to intercept fish before they could swim down and become stranded in drying pools. The location of the Pine Gulch trap site was determined in large part by access and security issues, since the lower 4.5 km of the mainstem is on mostly private lands. In 1999, a trap was installed on Marin County Open Space District lands 300 m upstream of the mouth, was subject to high public access and was vandalized. The current site is on private land about 2 km above the mouth, and was chosen with the cooperation of the landowner. The 2004 Olema mainstem site is located on NPS land approximately 400 m upstream of tidal influence and the confluence with Lagunitas Creek.

Traps are generally installed in mid-March, once winter flows have subsided and stabilized somewhat. In some years, spring rains occasionally raise flows enough to compromise trap operation. Stream flows usually drop substantially by late May or early June, so traps are usually removed at this time. A Hobo-brand temperature logger is deployed and left in each trap box for the duration of operation.

2.1 Rationale for selecting this sampling design

The location of the trap and watershed size plays a role in the equipment used to conduct smolt trapping. The current pipe trap design has been used successfully for seven years and continued use at the existing sites would allow consistency for this important long-term dataset. The largest watershed that is feasibly monitored using the pipe-style downstream migrant trap style is Pine Gulch Creek. This method could also be used on lower Redwood Creek. The fyke/pipe trap used on Olema Creek is a design more suitable for larger streams and higher flows (Gale 2000).

2.2 Field Methods

The traps are operated 24 hours per day, flow permitting, and checked once daily. All captured fish are removed from each trap, processed, and released back into the stream. Salmonids are identified to species and life stage (fry, parr, presmolt, smolt, resident, or adult). Age 1+ salmonids are anesthetized using Alkaseltzer, measured (fork length) to the nearest mm, and weighed to the nearest 0.1 g using an electronic scale. Anesthetized fish are allowed to recover fully in an aerated recovery bucket before release. Fry are identified to species, counted, and a subsample measured. Non salmonid fish and other aquatic species are also identified, aged if possible, measured, and weighed. Age 1+ steelhead and coho are separated into the following morphological categories: smolt (absence of parr marks, silver body, deciduous scales, black fin margins), parr (smaller size, parr marks), and pre-smolt (intermediate characteristics) (Bratovich and Kelley, 1988; Nelson 1994). In general, coho measuring more than 70 mm in the spring are assumed to be one year old and potential smolts. Steelhead which are smolt-sized or larger with no smolt characteristics, and which exhibit rainbow trout characteristics are classified as residents. Occasional runback steelhead spawners are trapped on their way back out to sea; they are generally >40 cm long and are classified as adults. Any mortality or injury is recorded as well as the probable cause.

In 2004, operations of the smolt traps were modified to increase efficiency and reduce handling stress to the fish. In the past, all 1+ fish were anesthetized, weighed, and measured, while only a subsample of fry were measured. With installation of trap locations in lower Olema Creek and Pine Gulch Creek, the number of fish encountered in the traps are much higher. Sub-sampling of fish to weigh and measure included following daily selection procedures.

2.2.1 0+ salmonid sampling techniques

A subsample of fry from each salmonid species are selected to be measured. A total of ten of each species are measured and placed in the recovery bucket. All other fry should be identified to species and tallied for the final daily count.

2.2.2 1+ salmonid sampling techniques

Randomly select 10 smolts/presmolts (or 20% - whichever is greater) of each species. These fish should be weighed, measured, marked, and released upstream to test trap efficiency. Fish recaptured in the trap will be documented and released downstream. The mark may be a fin clip (caudal) that may also be used for genetic analysis, or a dye mark administered with a pan-jet needless injector. This will insure that sampling numbers are adequate for detailed biotic analysis, as well as insure that enough fish are marked to estimate trap efficiency.

2.2.3 All other species

All other species encountered in the trap should be identified, and a sub-sample weighed and measured using the same techniques as described in section 2.2.2.

2.2.4 Tissue collection and handling

Tissue and scale samples are collected from some 1+ salmonids following NOAA Fisheries guidelines. Tissue samples are submitted to the NOAA - Fisheries Genetics Lab in Santa Cruz, California. Scale samples are processed in house to determine age-length relationships for different watersheds.

2.3 Operation of trap requiring mark-recapture techniques

Mark-recapture methods are used to estimate trap efficiency and smolt population size at the Olema Creek site and other trap designs that trap only a part of the water column. Daily, no more than 30 smolts of each species (coho and steelhead) are anesthetized with carbon dioxide and marked with small but identifiable fin clips or dye on fins using a needleless injector. Marked smolts are released immediately at a predetermined site no more than 200 m above the trap site. Mark combinations are alternated weekly.

Studies using similar methods have demonstrated little marking mortality and no fish will be held for retention or survival tests (Thedinga et al. 1994). A study using the same methodology on five northwestern California streams revealed that trap mortality was less than one percent for smolts and less than three percent for fry (Manning 2001). The highest mortality rates were associated with high flow.

Trap operations will be suspended if either smolt or fry mortality exceeds five percent during a one week period.

A simple Petersen estimator can be used to generate smolt population estimates from the mark-recapture data (Thedinga et al. 1994). Trap efficiency, the proportion of marked smolts recaptured, will be calculated as

$$\mathbf{E = R / M}$$

where R is the number of marked smolts recaptured and M is the number of marked smolts released. Trap efficiency can then be used to expand the unmarked catch and produce population estimates as

$$\mathbf{N = U / E}$$

where N is the estimated population size and U is the unmarked catch. The marked and recaptured fish from subsequent days should be pooled into strata before estimating N. The numbers of marked smolts recaptured and marked smolts released from each stratum can be tested for independence using a chi-square test. If no differences are detected, a single estimate of N can be made for the entire migration. Variances and 95 percent confidence intervals can be determined by the Bootstrap method using 1,000 iterations (Efron and Tibshirani 1986).

Mark/recaptured data can also be analyzed using DARR (Darroch Analysis with Rank Reduction), a software application (Bjorkstedt 2000) developed through the NMFS Southwest Fisheries Science Center. The software facilitates analysis of temporally stratified mark/recapture data based on methods developed by Darroch (1961).

Using the efficiency method to estimate population could result in overestimates of population. Estimates reported through this method would require the following assumptions: 1) there is no mortality of released fish; and 2) there is no residualization or behavior change (far more probable in steelhead than coho). Detailed methods for data analysis using the DARR method are documented and available online (Bjorkstedt 2000).

3.0 RESULTS

Annual summaries of trap operations for each year are provided in the Appendices. The data collected in 2004 as part of the smolt trapping monitoring efforts are presented in Sections 3.1 through 3.4.

3.1 John West Fork 2004:

During the 2004 outmigrant trapping study, the John West Fork trap was in place and fully operational for 65 days (from March 25 through May 28). Results are shown in Table 3.1.

The trap captured a total of 112 coho smolts and 63 steelhead 1+, including 17 smolts, 14 presmolts, 31 parr, and 1 resident. There were no 1+ salmonid mortalities. The recapture rate for marked coho smolts was 78% (18/23) and for marked steelhead 1+ was 33% (6/18). Peak capture for steelhead smolt/presmolts occurred in late March/early April (week 3) and for coho smolts in mid-late April (week 6).

Also captured during this season were 5708 fry, of which 1575 (28%) were coho and 4133 (72%) were steelhead. The coho YOY mortality rate for the duration of trap operation was 0.7% (11/1575) and the steelhead YOY mortality rate was 0.9% (39/4133). In addition to known mortalities, 12 steelhead 1+ were observed to be "fat" and possible fry eaters. Steelhead fry capture peaked in mid-April (week 5), and coho fry capture peaked in mid-late April (week 6).

Table 3.1 John West Fork Smolt Trap Summary, March 25 - May 28, 2004

			SH						CO	
			juvenile				adult			
	From	To	smolt	presmolt	parr	fry	Res	spawner	Fry	smolt
Week 1	13-Mar	19-Mar	n	n	n	n	n	n	n	n
Week 2 [a]	20–Mar	26-Mar	4	3	3	1	0	0	53	24
Week 3	27-Mar	2-Apr	8	5	12	19	0	0	269	26
Week 4	3-Apr	9-Apr	0	0	2	686	0	0	194	0
Week 5	10-Apr	16-Apr	0	0	0	2593	0	0	134	1
Week 6	17-Apr	23-Apr	5	5	14	370	1	0	767	61
Week 7	24-Apr	30-Apr	0	1	0	168	0	0	83	0
Week 8	1-May	7-May	0	0	0	128	0	0	41	0
Week 9	8-May	14-May	0	0	1	98	0	0	22	0
Week 10	15-May	21-May	0	0	0	44	0	0	10	0
Week 11[b]	22-May	28-May	0	0	0	26	0	0	2	0
Week 12	29-May	4-Jun	n	n	n	n	n	n	n	n
		TOTALS	**17**	**14**	**31**	**4133**	**1**	**0**	**1575**	**112**

Totals include mortalities.
n- trap not installed

[a] 3/25, first day of trap operation
[b] 5/28, last day of trap operation

3.1.1 Migration timing and environmental conditions

Smolt migration timing likely began prior to installation of the trap in association with the mild spring and early warm temperatures. The capture of coho fry and smolts during the first day and week of operation are indicative of this condition.

Movement through the traps in spring 2004 was highly influenced by the dry spring and warm temperatures in the area. Between March 1 and May 30, recorded precipitation at the Bear Valley Weather Station was 3.29 inches, or 36.5% of normal rainfall for that three month spring period. The outmigration peaks (Figures 3.1 through 3.4) for salmonids (with the exception of steelhead fry) occurred in conjunction with

the two spring rainfall events on March 25-27 (1.14 inches) and April 19-21 (1.12 inches). Water temperature also correlated with this same pattern, with warmer temperatures at all times, with the exception of these small storm flows (Figure 3.5). It is possible that the high outmigration of steelhead fry the week of April 10 (2,593 individuals) correlated with emergence from redds near the trap location.

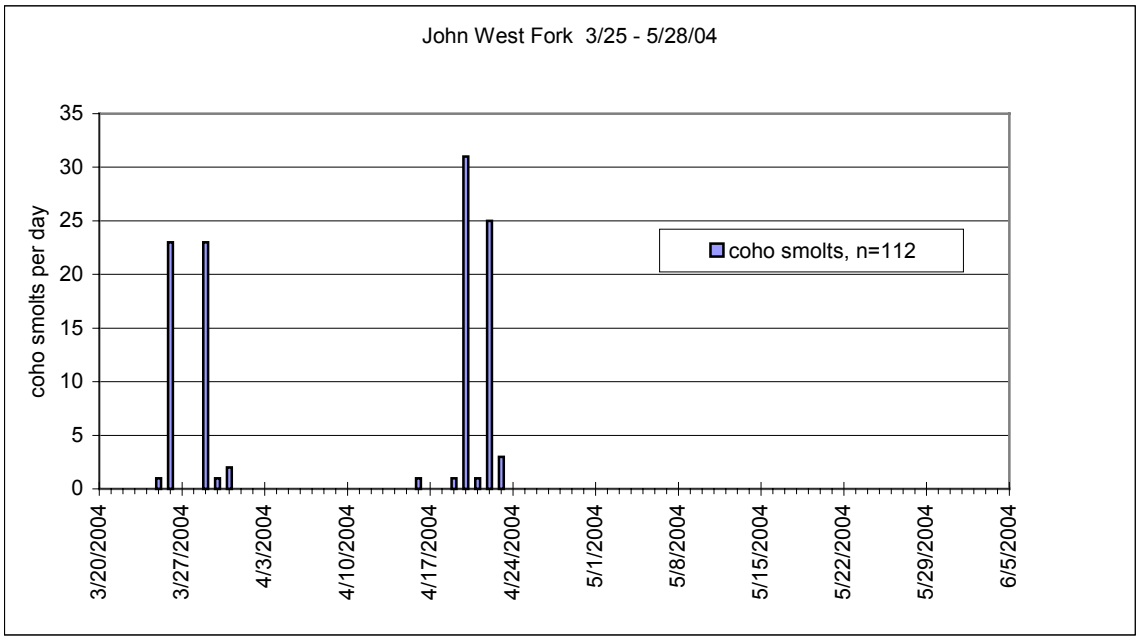

Figure 3.1 Daily total coho smolt (coho 1+) totals observed at the John West Fork Trap March 25, 2004 – May 28, 2004.

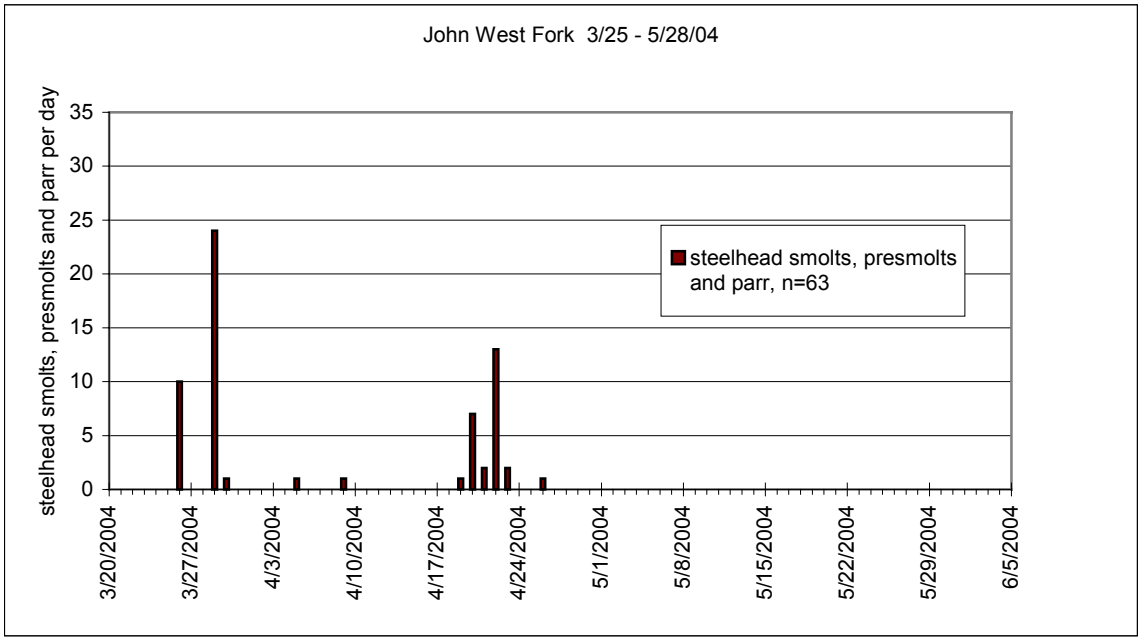

Figure 3.2 Daily total steelhead 1+ totals observed at the John West Fork Trap March 25, 2004 – May 28, 2004.

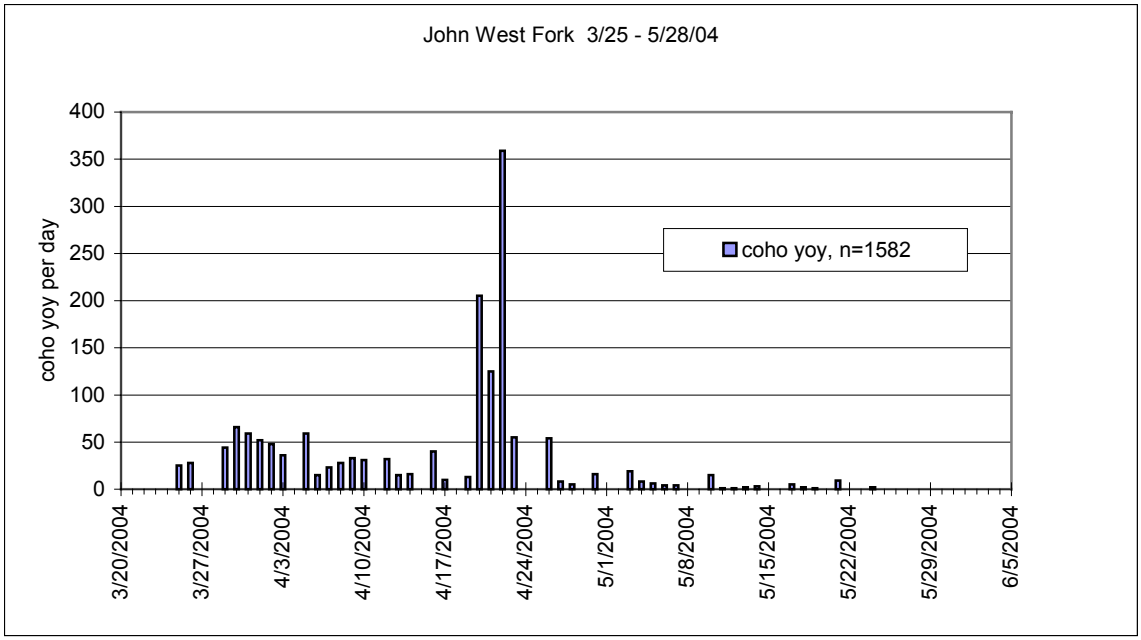

Figure 3.3 Daily total coho fry (coho 0+) totals observed at the John West Fork Trap March 25, 2004 – May 28, 2004.

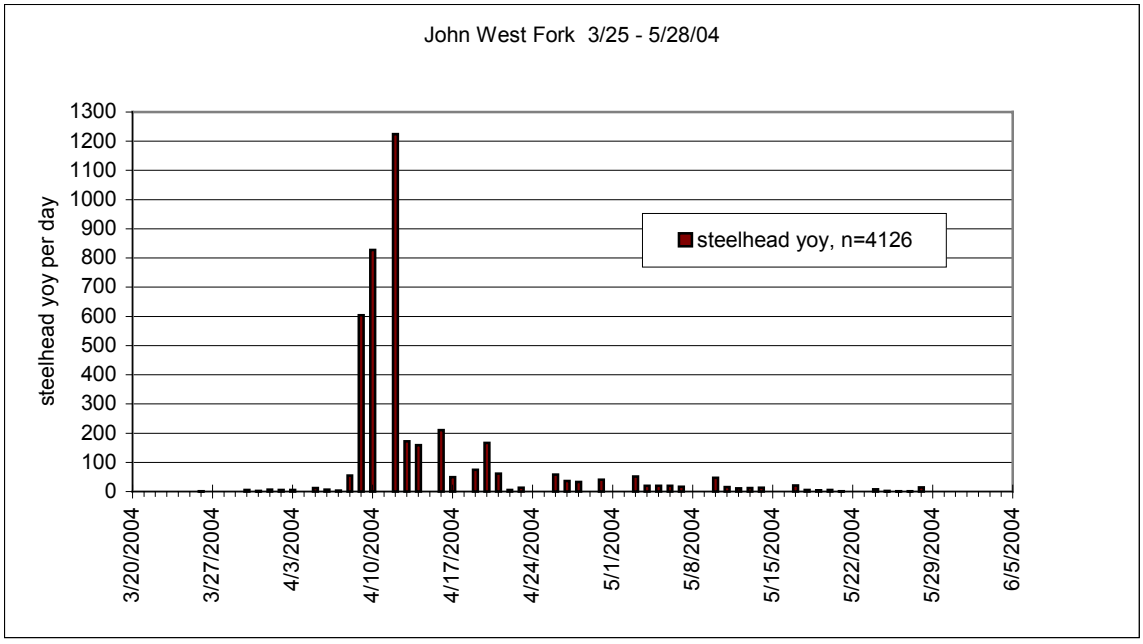

Figure 3.4 Daily total steelhead fry (0+) totals observed at the John West Fork Trap March 25, 2004 – May 28, 2004.

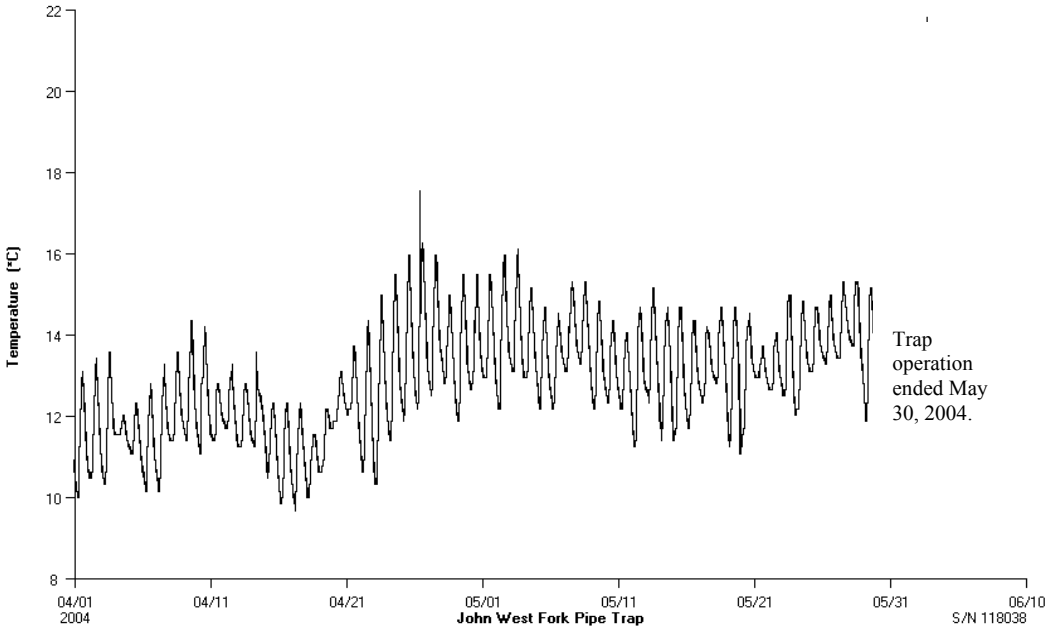

Figure 3.5 Water Temperature at John West Fork Trap site April 1 – May 30, 2004.

3.1.2 Fish condition and measurement

Weight and length measurements were made on a subsample of the fish observed in the trapping operations. Histograms of salmonid fork length are presented as Figure 3.6 (coho) and Figure 3.7 (steelhead). A weight-length comparison of salmonids captured at all three sites in 2004 is presented in section 3.4.

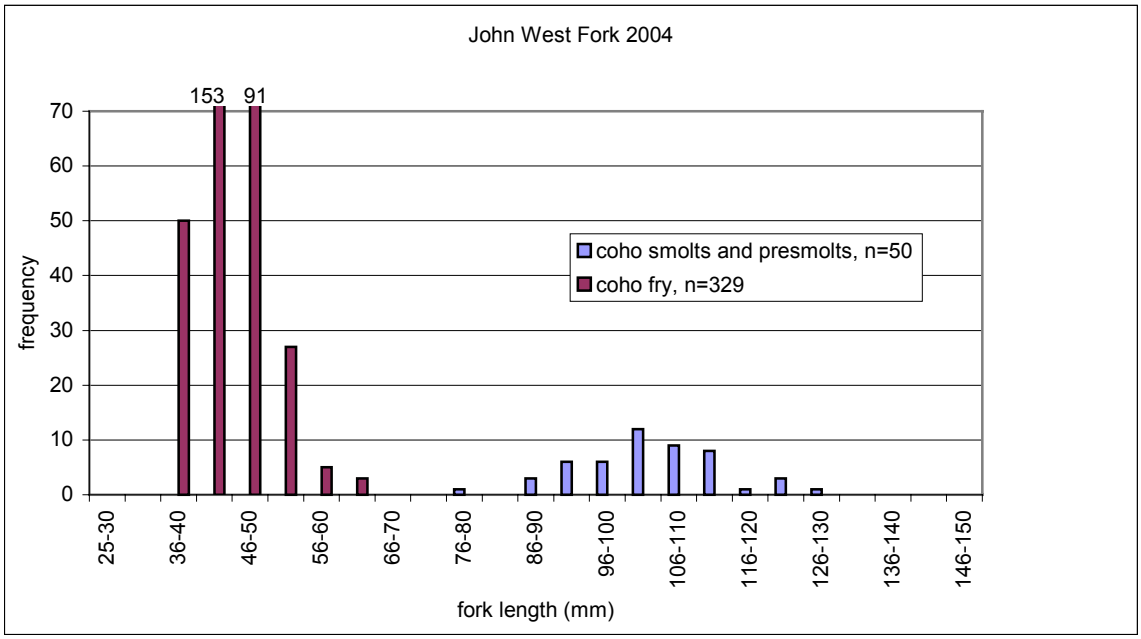

Figure 3.6 Fork length histogram of coho salmon measured at the John West Fork outmigrant trap March 25, 2004 - May 28, 2004.

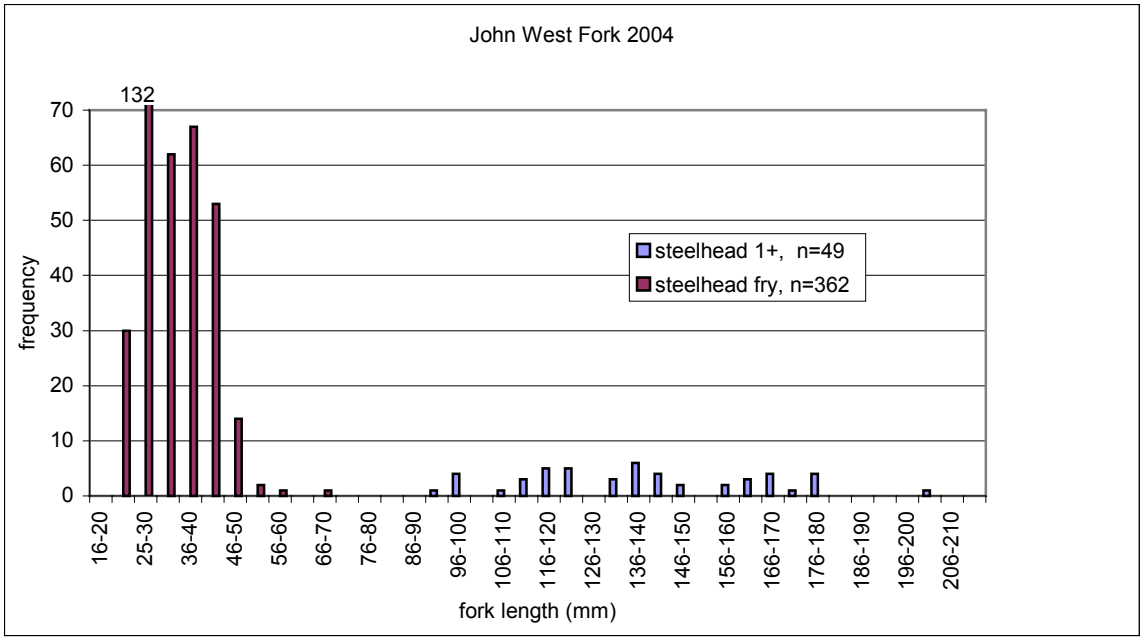

Figure 3.7 Fork length histogram of steelhead measured at the John West Fork outmigrant trap March 25, 2004 - May 28, 2004.

3.2 Olema Creek 2004:

For the first time in 2004, the salmonid monitoring efforts included operation of a fyke/pipe style trap at the downstream end of Olema Creek. The Olema Creek trap was in place for 60 days (from March 30 through May 28) and was fully operational for 57 days. On 5/10 the upper mouth of the pipe was observed to be clogged with enough debris to prevent fish passage. On 5/12 and 5/13 there was no longer enough water flowing down the stream to force water all the way through the pipe. The ramp was removed, and the pipe lowered and extended directly into the box. On 5/14 the trap was again working with enough water flow to allow fish passage.

The trap captured a total of 229 coho smolts and 18 steelhead 1+, including 11 smolts, 2 presmolts, and 5 parr. The mortality rate for 1+ coho was 3.1% (7/229). There were no 1+ steelhead mortalities. The overall recapture rate for 1+ coho was 24% (29/122). DARR analysis of the coho smolt data stratified by week (figure 3.1) showed the estimated capture probability at around 37% for the first five weeks of trap operation, then dropping to around 17% for the last four weeks, resulting in a total coho smolt estimate of 830.6 (±167.2 s.d.). Two coho smolts were captured in the Olema trap that had been marked with caudal fin clips and released from the John West Fork trap, 10.5 km upstream. No steelhead 1+ were recaptured although 12 were marked and released above the trap. The Olema trap was built with a bypass to allow adult steelhead spawners to migrate up and downstream past the weir, possibly explaining why no marked steelhead 1+ were recaptured. Peak capture for both steelhead smolt/presmolts and coho smolts occurred in mid-late April, during week 6.

In addition to coho and steelhead, 2 chinook salmon smolts were also captured this year. These are the first documented chinook salmon identified in Olema Creek. The first was captured on 4/21 and the second on 5/3. Both were 85mm long and weighed 6.7 and 6.6g, respectively. Both were released below the trap unmarked.

Also captured during this season were 172 fry, of which 32 (19%) were coho and 140 (81%) were steelhead. Steelhead fry capture peaked in mid-late April (week 6), and coho fry capture peaked in late April (week 7). The coho YOY mortality rate for the duration of trap operation was 3.1% (1/32) and the steelhead YOY mortality rate was 2.1% (3/140). In addition to known mortalities, 9 sculpin were observed to be "fat" and possible fry eaters. One sculpin was observed with the tail of a stickleback hanging out of its mouth, which makes it hard to discern what the other 9 sculpin had been eating.

Table 3.2 Olema Creek Smolt Trap Summary, March 30 –May 28, 2004

			SH						CO	
			juvenile				adult			
	From	To	smolt	presmolt	parr	fry	Res	spawner	Fry	smolt
Week 1	13-Mar	19-Mar	n	n	n	n	n	n	n	n
Week 2 [a]	20–Mar	26-Mar	n	n	n	n	n	n	n	n
Week 3	27-Mar	2-Apr	0	0	0	0	0	0	0	11
Week 4	3-Apr	9-Apr	0	0	0	0	0	0	0	4
Week 5	10-Apr	16-Apr	1	0	0	0	0	0	0	15
Week 6	17-Apr	23-Apr	9	0	2	26	0	0	10	80
Week 7	24-Apr	30-Apr	1	2	2	13	0	0	17	53
Week 8	1-May	7-May	0	0	1	12	0	0	5	40
Week 9	8-May	14-May	0	0	0	8	0	0	0	15
Week 10	15-May	21-May	0	0	0	29	0	0	0	8
Week 11[b]	22-May	28-May	0	0	0	52	0	0	0	3
Week 12	29-May	4-Jun	n	n	n	n	n	n	n	n
		TOTALS	**11**	**2**	**5**	**140**	**0**	**0**	**32**	**229**

n- trap not installed

[a] 3/30, first day of trap operation

[b] 5/28, last day of trap operation

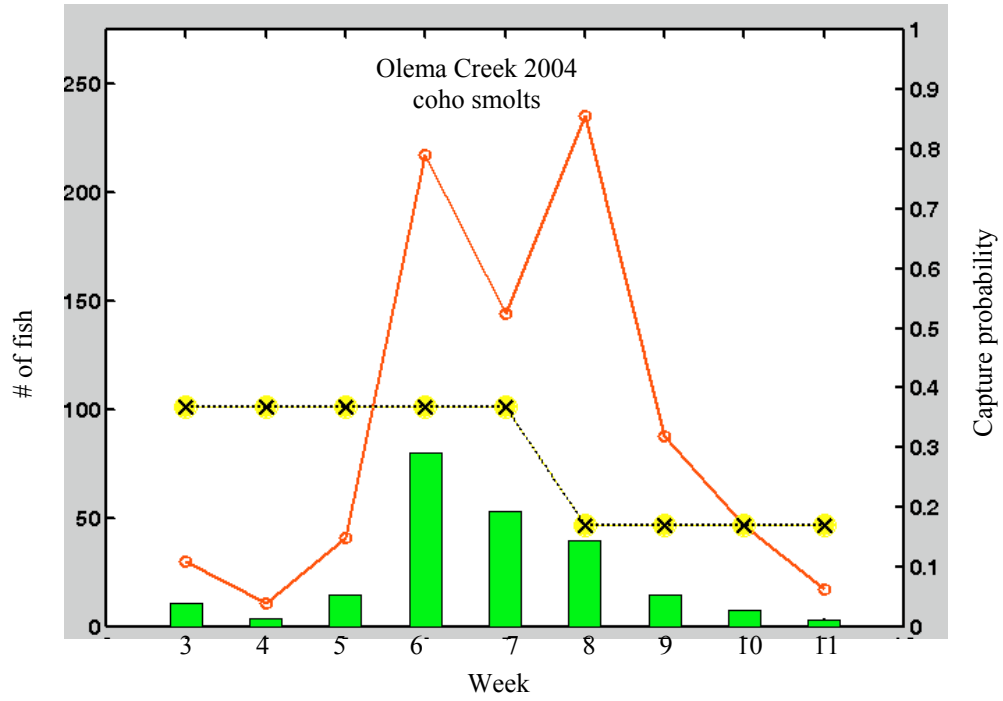

Figure 3.8 DARR output graph of coho smolt outmigration by week: # of fish captured (bars), estimated total # of fish (solid line with o's), and estimated capture efficiency (dotted line with x's) for each week. Olema creek smolt trap, spring 2004. DARR analysis of the coho smolt data stratified by week showed the estimated capture probability at around 37% for the first five weeks of trap operation, then dropping to around 17% for the last four weeks, resulting in a total coho smolt estimate of 830.6 (±167.2 s.d.).

3.2.1 Migration timing and environmental conditions

Smolt migration timing likely began prior to installation of the trap in association with the mild spring and early warm temperatures. The capture of coho fry and smolts during the first day and week of operation are indicative of this condition.

Movement through the traps in spring 2004 was highly influenced by the dry spring and warm temperatures in the area. Between March 1 and May 30, recorded precipitation at the Bear Valley Weather Station was 3.29 inches, or 36.5% of normal rainfall for that three month spring period. The outmigration peaks (Figures 3.9 through 3.12) for salmonids (with the exception of steelhead fry) occurred in conjunction with the two spring rainfall events on March 25-27 (1.14 inches) and April 19-21 (1.12 inches). Water temperature also correlated with this same pattern, with warmer temperatures at all times, with the exception of these small storm flows (Figure 3.13).

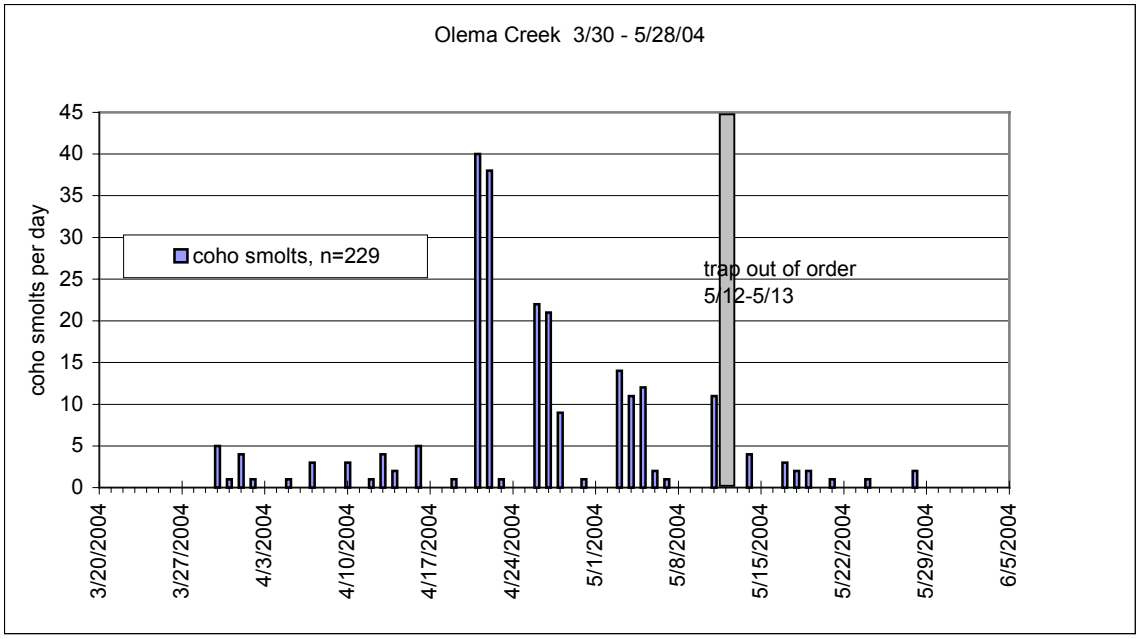

Figure 3.9 Daily total coho smolt (1+) totals observed at the Olema Creek Trap March 30, 2004 – May 28, 2004.

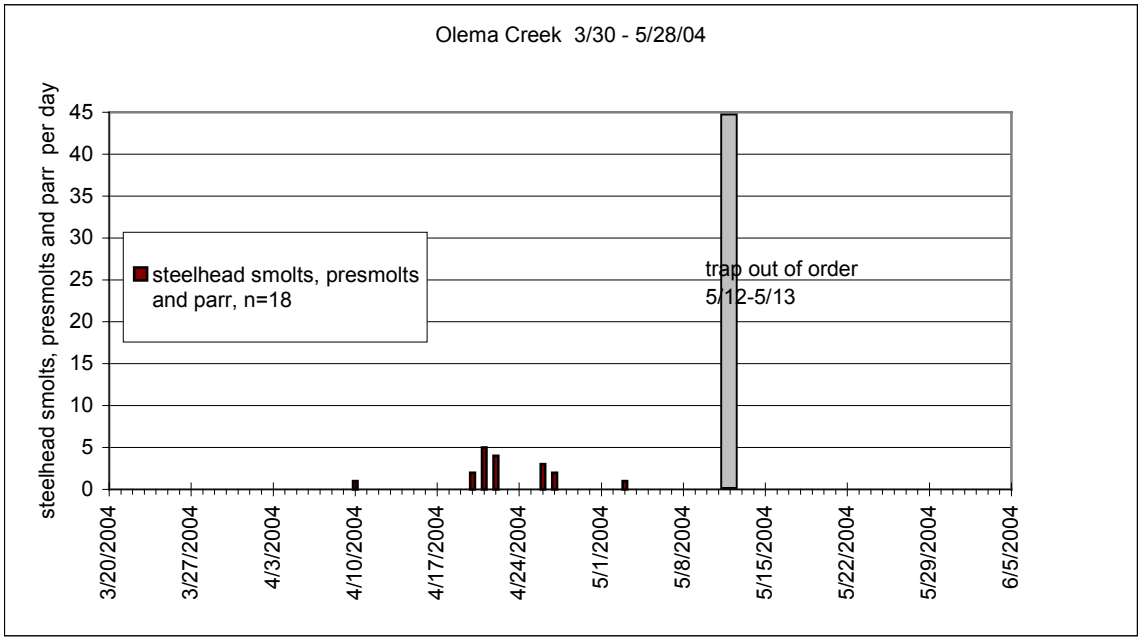

Figure 3.10 Daily total steelhead (1+) totals observed at the Olema Creek Trap March 30, 2004 – May 28, 2004.

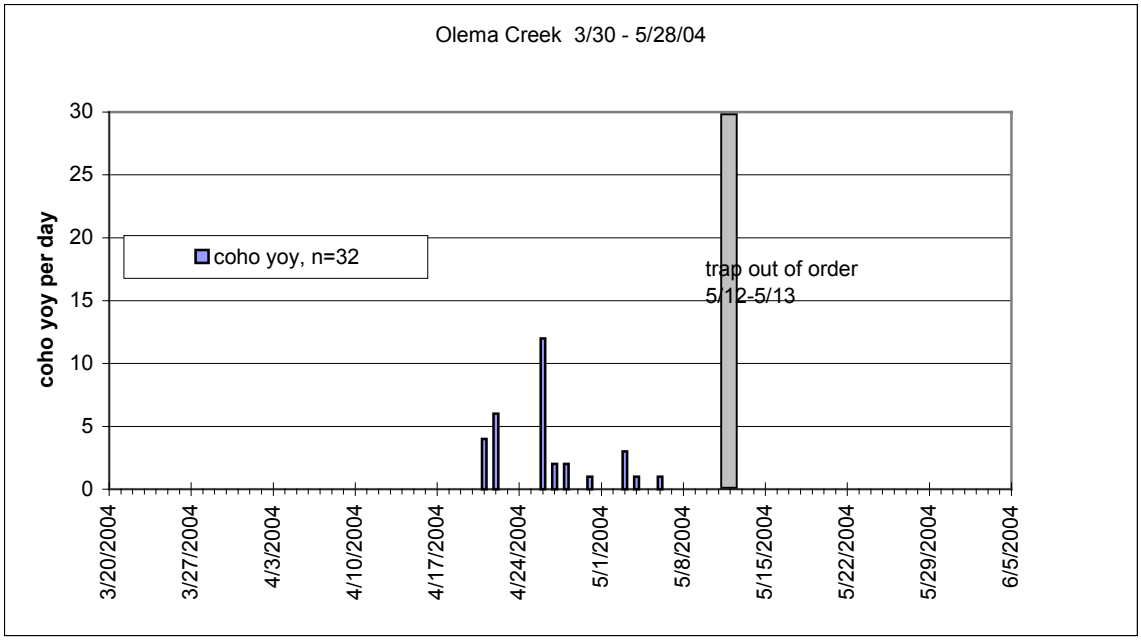

Figure 3.11 Daily total coho fry (0+) totals observed at the Olema Creek Trap March 30, 2004 – May 28, 2004.

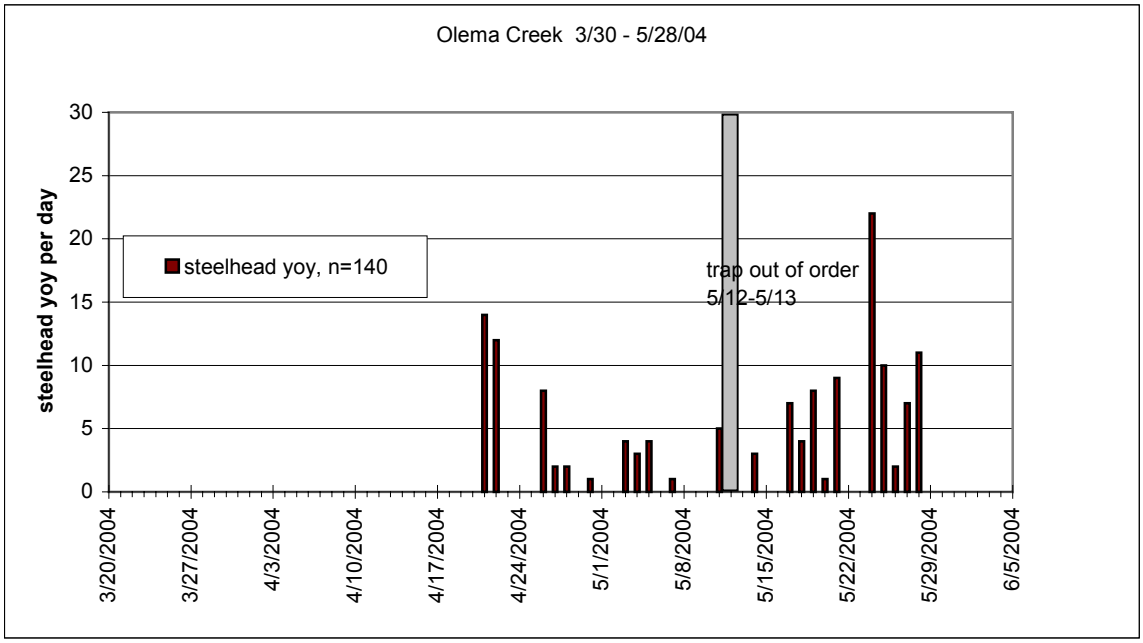

Figure 3.12 Daily total steelhead fry (0+) totals observed at the Olema Creek Trap March 30, 2004 – May 28, 2004.

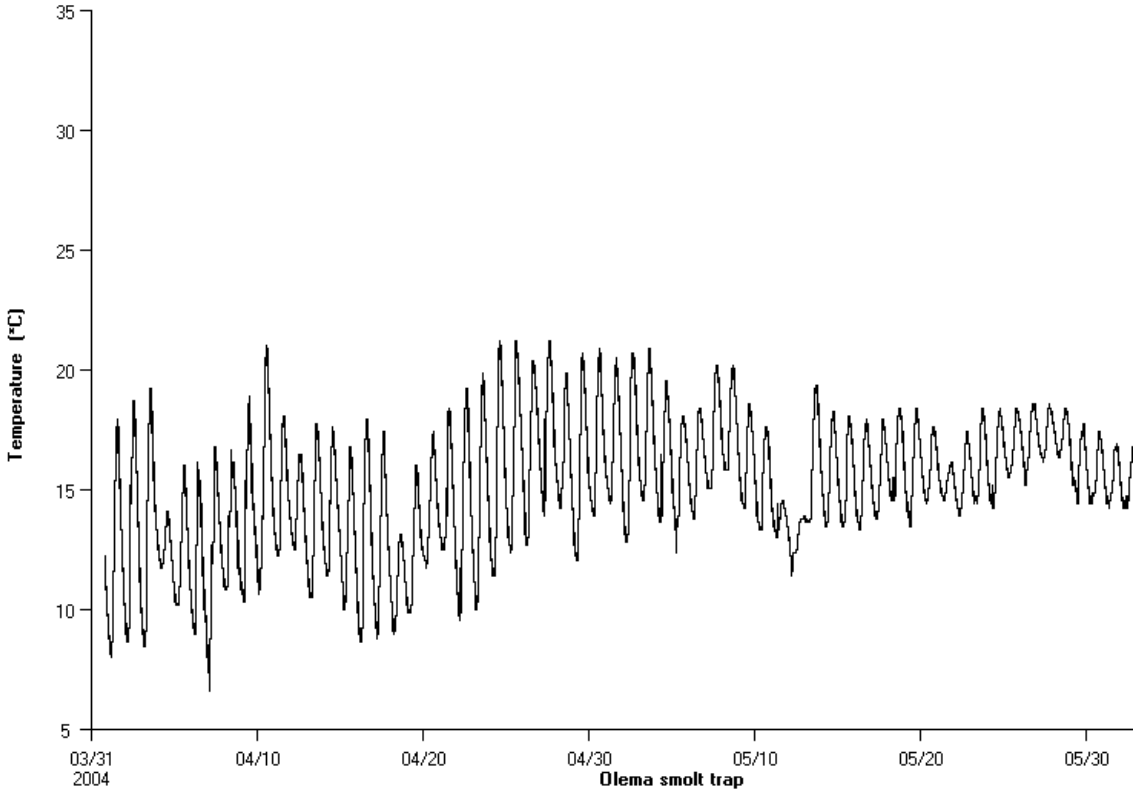

Figure 3.13 Water Temperature at the Olema Creek outmigrant trap site April 1 – May 30, 2004.

3.2.2 Fish condition and measurement

Weight and length measurements were made on a subsample of the fish observed in the trapping operations. Histograms of salmonid fork length are presented as Figure 3.14 (coho) and Figure 3.15 (steelhead). A weight-length comparison of salmonids captured at all three sites in 2004 is presented in section 3.4.

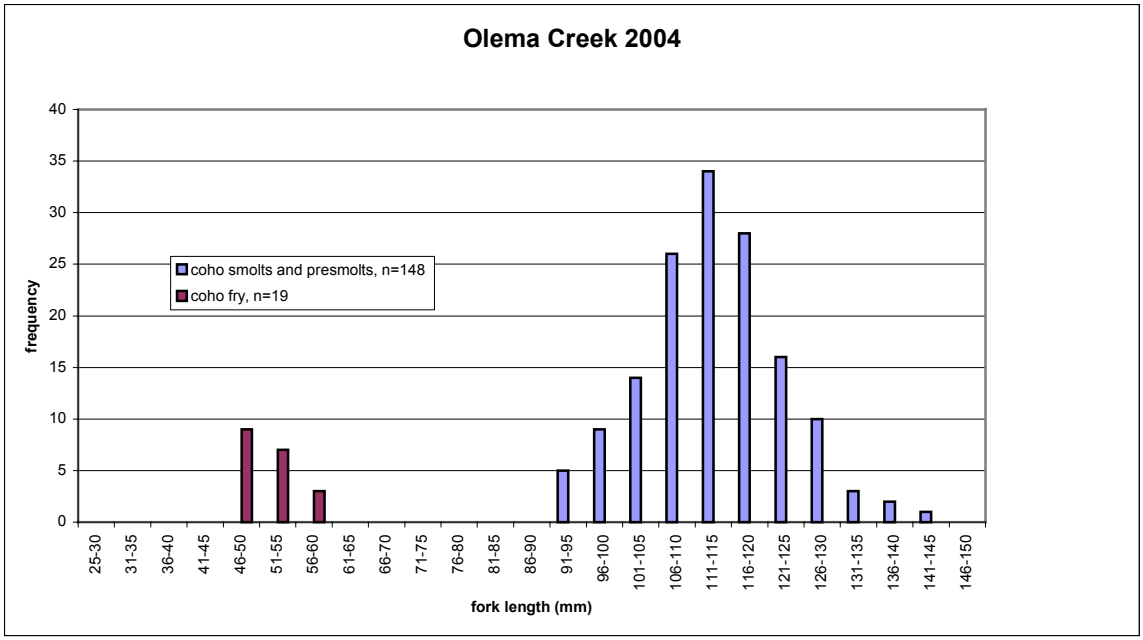

Figure 3.14 Fork length histogram of coho salmon measured at the Olema Creek outmigrant trap March 30, 2004 - May 28, 2004.

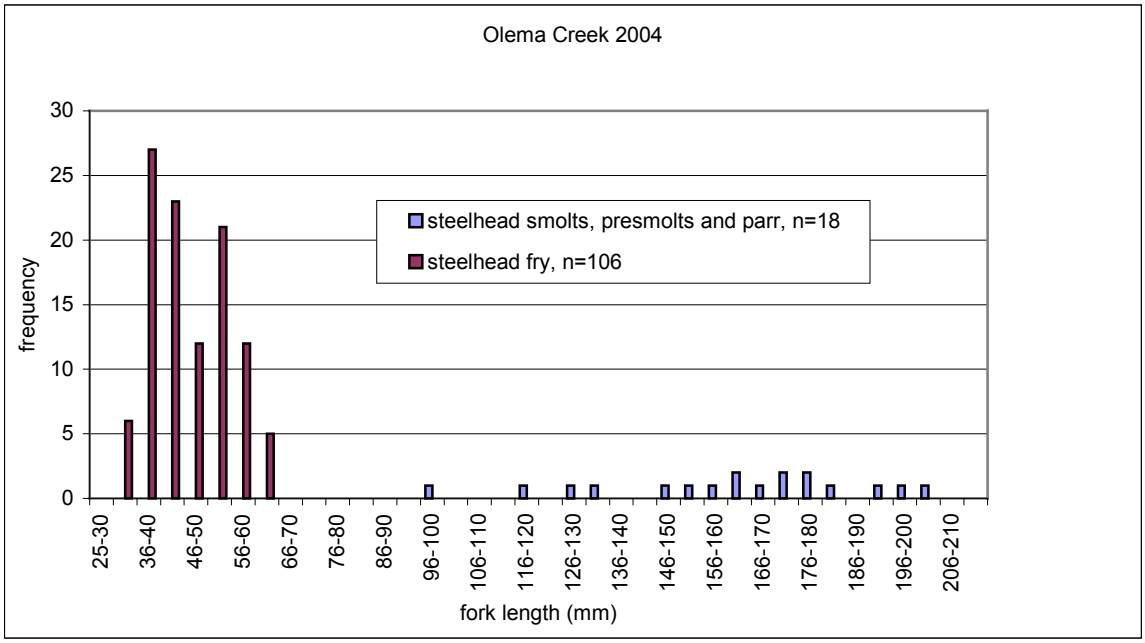

Figure 3.15 Fork length histogram of steelhead measured at the Olema Creek outmigrant trap March 30, 2004 - May 28, 2004.

3.3 Pine Gulch 2004:

During the 2004 outmigrant study, the Pine Gulch trap was in place for 65 days (from March 25 through May 28), and was fully operational for 61 days. The trap was overwhelmed by high flows from spring rains on March 26. Heavy pressure within the trap box necessitated opening the box and releasing the fish before they could be tallied. The trap was left open for 3 more days until flows receded, and was fully operational again on March 30. It was very effective for trapping 1+ coho and steelhead, but relatively ineffective for trapping fry due to water continuously passing through the screen weir.

The trap captured a total of 149 coho smolts and 99 steelhead 1+, including 38 smolts, 11 presmolts, and 50 parr. The mortality rate for coho smolts was 1.3% (2/149) and for steelhead 1+ was 1.0% (1/99). Another steelhead parr was found dead above the weir on 4/13. This parr was probably not killed by the trap and was not included in capture totals. Two unidentified salmonid 1+ were killed from the heavy pressure of flows in the trap box on March 26. These fish are also not included in capture totals, as they were never identified. This year, the trap was built with a bypass around the weir that allowed spawning steelhead adults to navigate past the trap on their way upstream. In fact, a fresh steelhead redd was observed upstream of the weir after the trap was installed. Due to the bypass, capture efficiency of 1+ salmonids when the trap was fully operational may have been less than in previous years. The overall recapture rate for marked steelhead 1+ was 4% (2/49) and for coho 1+ was 20% (22/108). DARR analysis of the coho smolt data stratified by week (figure 3.2) showed the estimated capture probability remained consistent at around 20% throughout the trapping period, and resulted in a total coho smolt estimate of 737.7 (±143.8 s.d.). Peak capture for coho smolts occurred in late May during week 9. Peak capture of steelhead smolts/presmolts occurred equally during weeks 3,4 and 6, spanning late March through late April.

Also captured during this season were 57 steelhead fry. No coho fry were captured. The steelhead YOY mortality rate for the duration of trap operation was 17.5 % (10/57). Four of these fry mortalities were observed to be probably regurgitated by other fish. In addition to known mortalities, six steelhead 1+ were observed to be "fat" and probable fry eaters. Peak capture for steelhead fry was in mid-late April during week 6.

Table 3.3 Pine Gulch Smolt Trap Summary, March 25 – May 28, 2004

			SH						CO	
			juvenile				adult			
	From	To	smolt	presmolt	parr	fry	Res	spawner	Fry	smolt
Week 1	13-Mar	19-Mar	n	n	n	n	n	n	n	n
Week 2 [a]	20–Mar	26-Mar	1	1	1	0	0	0	0	0
Week 3 [b]	27-Mar	2-Apr	8	6	5	9	0	0	0	9
Week 4	3-Apr	9-Apr	11	3	6	0	0	0	0	16
Week 5	10-Apr	16-Apr	3	1	9	0	0	0	0	21
Week 6	17-Apr	23-Apr	14	0	22	21	0	0	0	18
Week 7	24-Apr	30-Apr	1	0	3	4	0	0	0	11
Week 8	1-May	7-May	0	0	2	3	0	0	0	25
Week 9	8-May	14-May	0	0	1	15	0	0	0	48
Week 10	15-May	21-May	0	0	1	5	0	0	0	1
Week 11[c]	22-May	28-May	0	0	0	0	0	0	0	0
Week 12	29-May	4-Jun	n	n	n	n	n	n	n	n
		TOTALS	**38**	**11**	**50**	**57**	**0**	**0**	**0**	**149**

Totals include mortalities.
n- trap not installed

[a] 3/25, first day of trap operation – 3/26, trap not operational
[b] 3/27-3/29, trap not operational
[c] 5/28, last day of trap operation

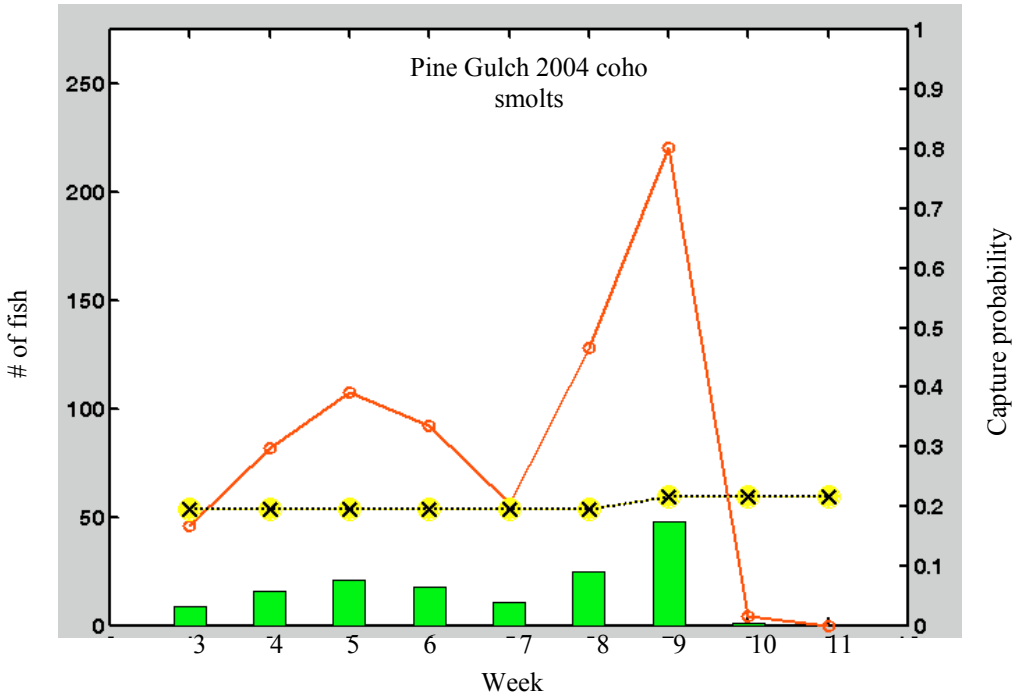

Figure 3.16 DARR output graph of coho smolt outmigration by week: # of fish captured (bars), estimated total # of fish (solid line with o's), and estimated capture efficiency (dotted line with x's) for each week. Pine Gulch smolt trap, spring 2004. The estimated capture probability remained consistent at around 20% throughout the trapping period, and resulted in a total coho smolt estimate of 737.7 (±143.8 s.d.).

3.3.1 Migration timing and environmental conditions

Smolt migration timing likely began prior to installation of the trap in association with the mild spring and early warm temperatures. The capture of coho fry and smolts during the first day and week of operation are indicative of this condition.

Movement through the traps in spring 2004 was highly influenced by the dry spring and warm temperatures in the area. Between March 1 and May 30, recorded precipitation at the Bear Valley Weather Station was 3.29 inches, or 36.5% of normal rainfall for that three month spring period. Unlike Olema Creek and John West Fork, the perennial flow and channel condition did not likely constrain outmigration to weather or flow events. The outmigration pattern for coho and steelhead shows less pattern related to rainfall or flow, (Figures 3.17 through 3.19). Water temperature also correlated with this same pattern, with warmer temperatures at all times, with the exception of these small storm flows (Figure 3.20).

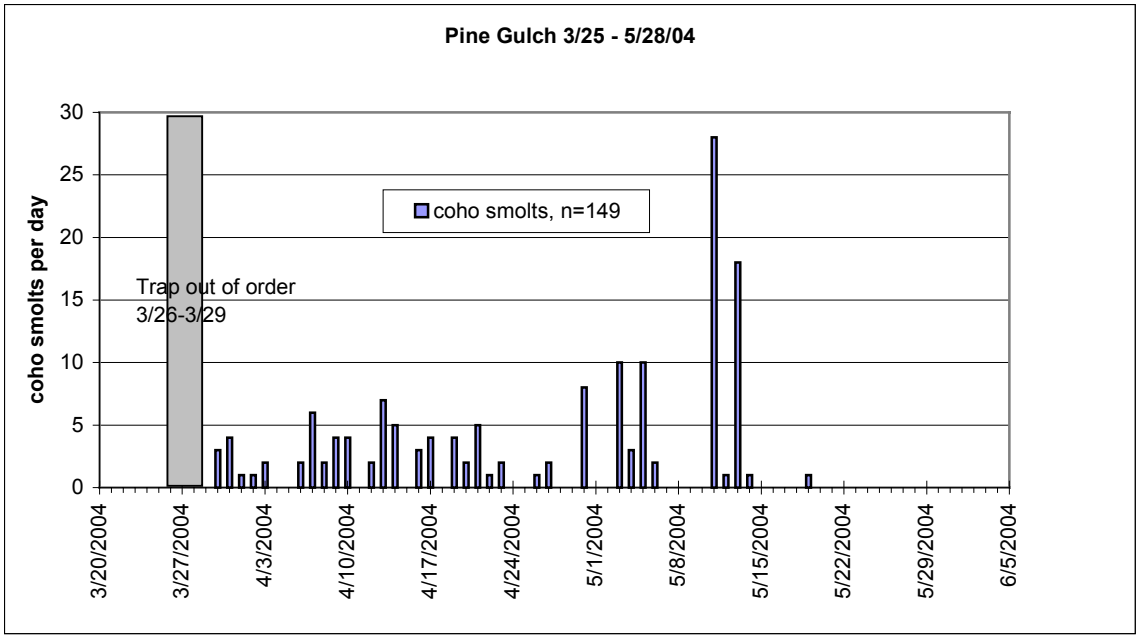

Figure 3.17 Daily total coho smolts (1+) totals observed at the Pine Gulch Creek Trap March 25, 2004 – May 28, 2004.

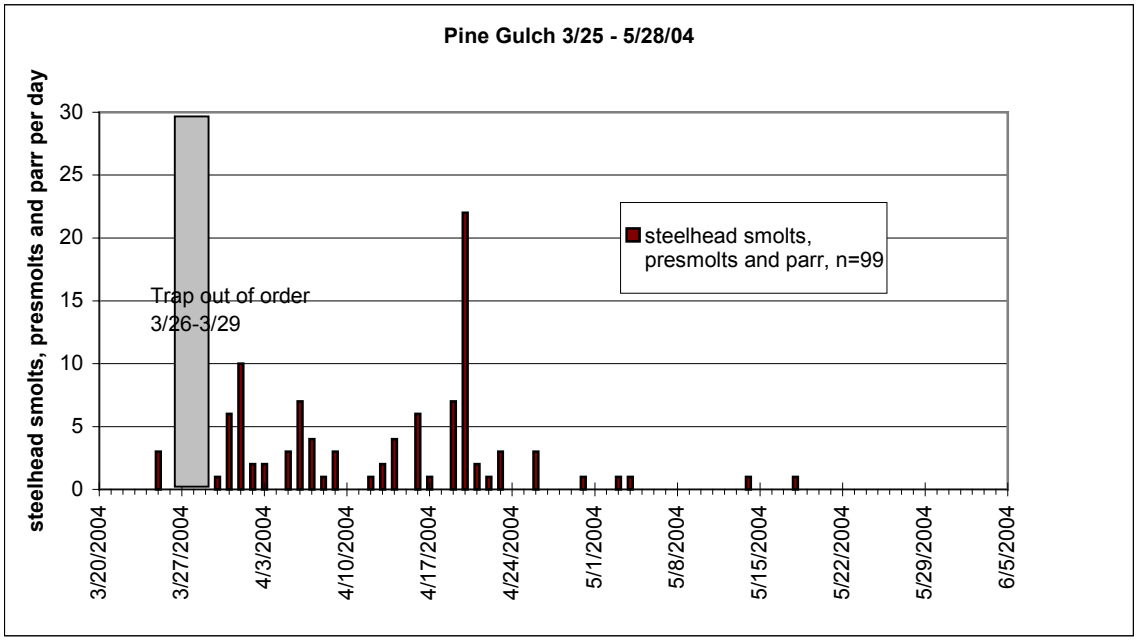

Figure 3.18 Daily total steelhead (1+) totals observed at the Pine Gulch Creek Trap March 25, 2004 – May 28, 2004.

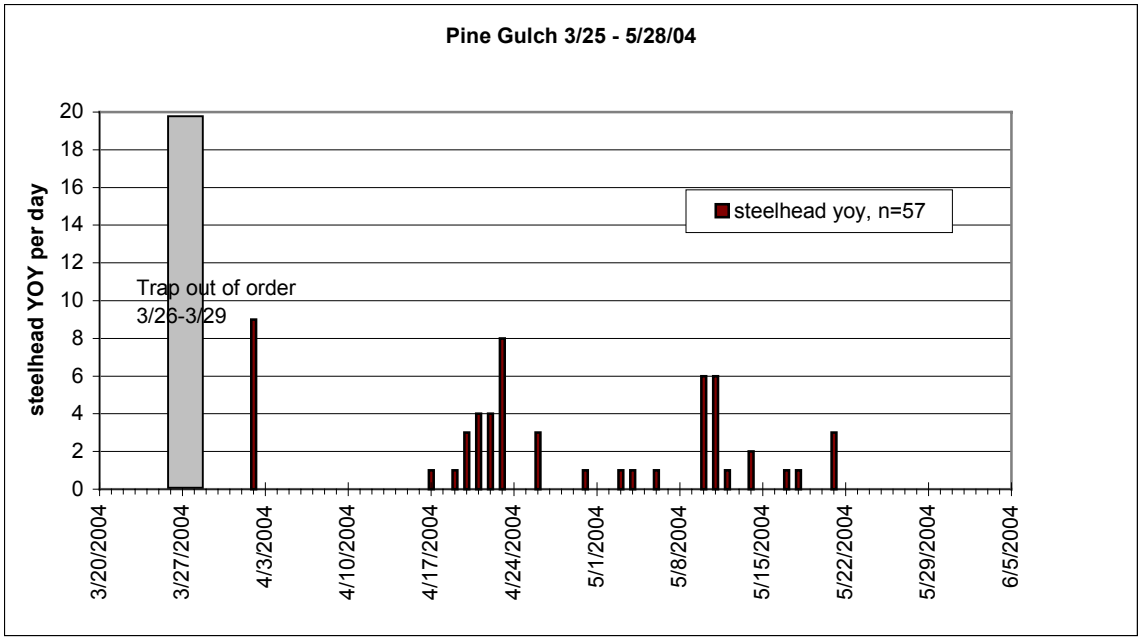

Figure 3.19 Daily total steelhead fry (0+) totals observed at the Pine Gulch Creek Trap March 25, 2004 – May 28, 2004.

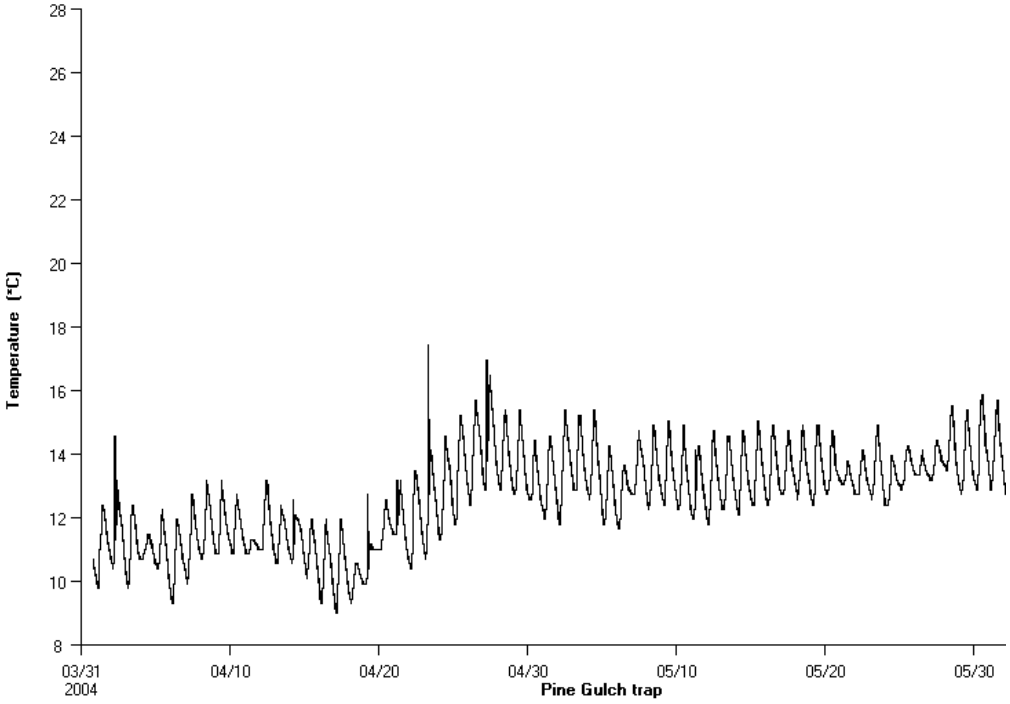

Figure 3.20 Water Temperature at the Olema Creek outmigrant trap site April 1 – May 30, 2004.

3.3.2 Fish condition and measurement

Weight and length measurements were made on a subsample of the fish observed in the trapping operations. Histograms of salmonid fork length are presented as Figure 3.21 (coho) and Figure 3.22 (steelhead). A weight-length comparison of salmonids captured at all three sites in 2004 is presented in section 3.4.

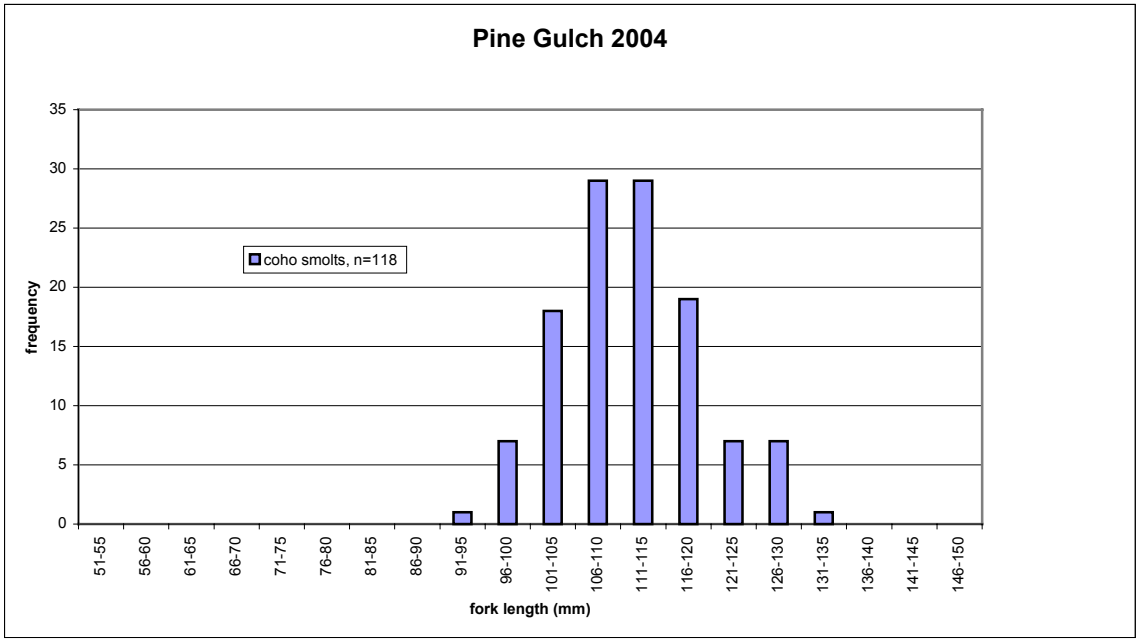

Figure 3.21 Fork length histogram of coho measured at the Pine Gulch Creek outmigrant trap March 25, 2004 - May 28, 2004.

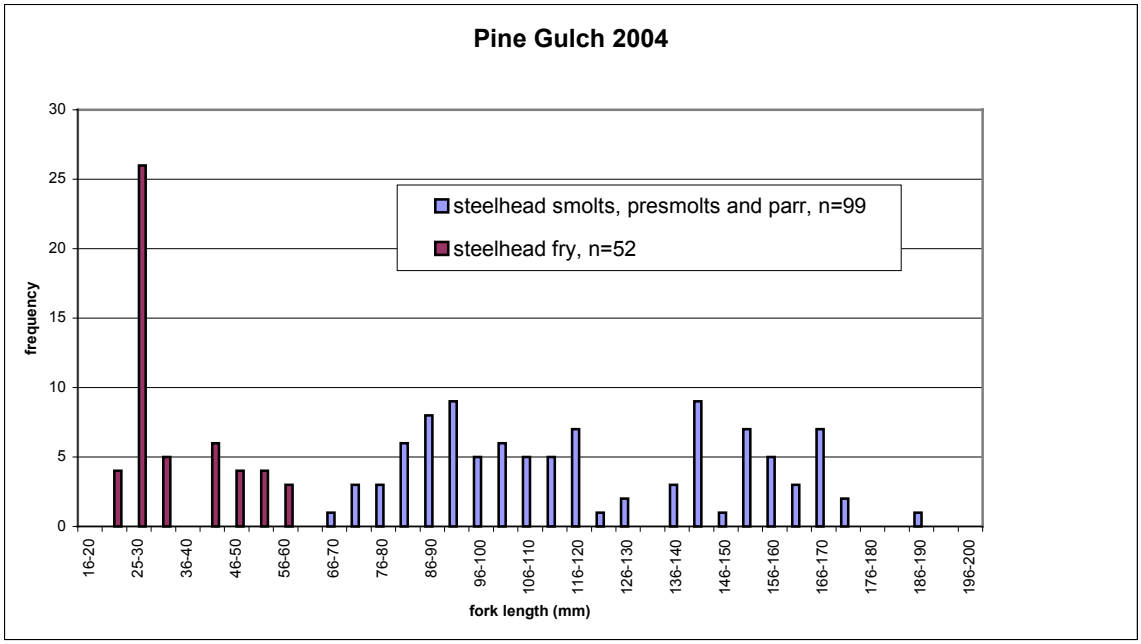

Figure 3.22 Fork length histogram of steelhead measured at the Pine Gulch Creek outmigrant trap March 25, 2004 - May 28, 2004.

3.4 Weight Length watershed comparisons

Comparisons among all three monitoring sites of salmonid weight-length curves are presented for coho and steelhead.

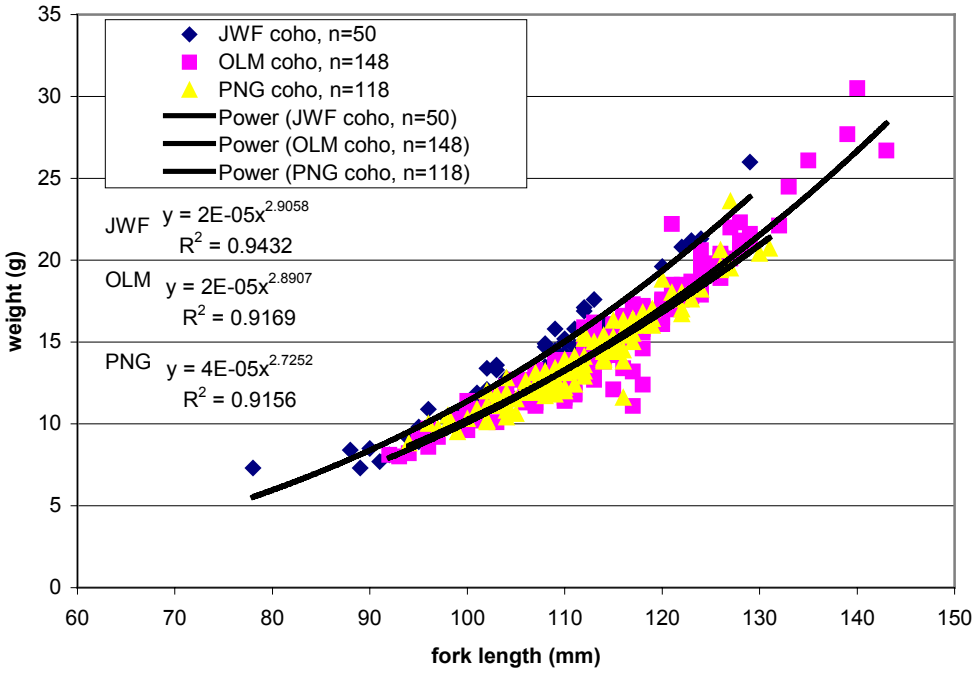

Figure 3.23 Comparison of coho 1+ weight length relationships in Pine Gulch Creek, Olema Creek, and John West Fork of Olema Creek, Marin County, CA spring 2004.

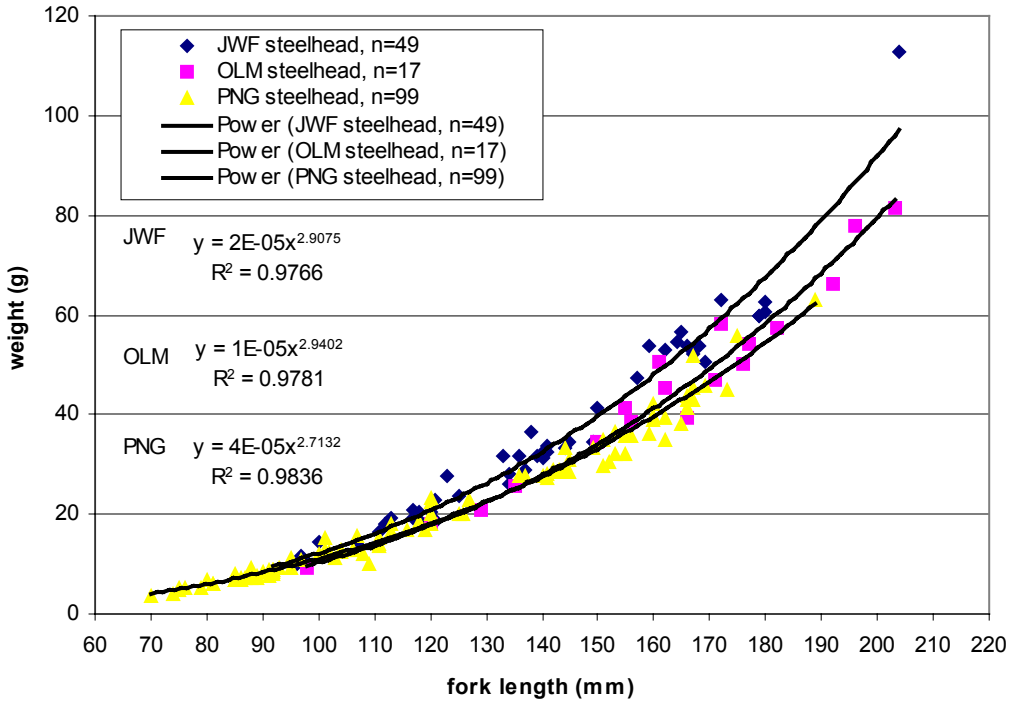

Figure 3.24 Comparison of steelhead 1+ weight length relationships in Pine Gulch Creek, Olema Creek, and John West Fork of Olema Creek, Marin County, CA spring 2004.

4.0 1998-2003 JOHN WEST FORK SUMMARY INFORMATION

4.1 Smolt outmigration timing

The outmigrant traps are operated between mid-March and June of each year. While it is likely that smolts are moving past the trap location beginning in February, the results show that the peak of outmigration occurs in early April of each year. Outmigration within the John West Fork is affected by weather patterns, typically showing an increase with rainfall and runoff events. In the John West Fork, young of year salmon have also been observed to move with storm or foggy conditions.

Evaluation of the annual data for the John West Fork shows a dramatic increase in smolt and juvenile production in association with the SY 2000-01 and SY 2001-02.

Table 4.1. Summary information for John West Fork trap operations spring 1998 – spring 2003.

	Trap Operation Dates		SH						CO	
			Juvenile				Adult			
	From	To	smolt	presmolt	Parr	fry	Resident	Ocean-run	Fry	smolt
1998	20-Mar	20-Aug	30	12	2	6599 [a]	8	0	1,061 [a]	21
1999*	12-Mar	1-Jul	15	22	14	228	2	6	0	0
2000*	29-Mar	19-Jul	2	25	22	6620	2	1	14	0
2001*	14-Mar	4-Jun	10	19	72	481	1	0	6563	3
2002*	19-Mar	11-Jun	18	5	8	269	0	0	5711	104
2003	22-Mar	30-May	18	25	3	1962 [b]	3	1	1561 [b]	181

[a] 1,061 fry originally identified as coho were probably steelhead
[b] number does not include 62 unidentified fry
*includes totals from upper trap

For the John West Fork trap observations are evaluated as production per kilometer, assuming that the habitat area upstream of the trap area is 2.0 kilometers. Results presented in tables 4.1 and 4.2 show a wide variability in juvenile production for both coho salmon and steelhead trout, as well as an increasing trend in coho smolt production since fish passage restoration in 1999.

Table 4.2. John West Fork trap density estimates (fish per meter) resulting from spring trapping operations 1998 – 2003.

	Steelhead (SH)					Coho (CO) density / m	
	Juvenile density / m						
	smolt	presmolt	Parr	fry		Fry	smolt
1998	0.015	0.006	0.001	3.299 [a]		0.530 [a]	0.011
1999*	0.008	0.011	0.007	0.114		0	0
2000*	0.001	0.013	0.011	3.310		0.007	0
2001*	0.005	0.010	0.036	0.241		3.282	0.002
2002*	0.009	0.003	0.004	0.135		2.856	0.052
2003	0.009	0.013	0.002	0.981 [b]		0.755 [b]	0.091

[a] fry originally identified as coho were probably steelhead
[b] number does not include 62 unidentified fry
*includes totals from upper trap

4.2 Smolt size and condition

A variety of research has shown that ocean survival of smolts is dependent on fish size as they enter the ocean. Within intermittent stream systems such as the John West Fork, fish tend to grow in the spring and early summer

when feeding conditions are best. In the summer, as surface flow recedes supporting isolated, intermittent pools, water temperatures increase and the food supply decreases dramatically. We have observed pools becoming isolated between June and October, and yet supporting salmonid survival (both coho and steelhead). We also frequently observed temperature and dissolved oxygen stratification in these pool units, with cool water and adequate DO near the bottom. As part of the California Department of Fish and Game - Russian River coho salmon broodstock reintroduction program (RRCBRP), coho were captured from intermittent sections of Olema Creek and Jon West Fork in 2001-2003. The fish condition at the time they were captured (late summer - September) was marginal. Fish were observed to be very small and skinny compared with fish captured from areas with perennial flow. It is our deduction that feeding rates are reduced during these low flow summer months, and that the John West Fork reared fish must quickly catch up in the late fall – prior to major winter storms, and spring, before outmigrating to the ocean. It is clear that these fish have the capacity to "catch up" as shown in growth patterns of the fish captured through the RRCBRP, where undersized Olema watershed fish caught up to their counterparts within the first few months of hatchery feeding operations (Wilson 2004 personal communication).

Staff record length and weight of the fish captured in the traps. Smolts outmigrating through the John West Fork over the past six years have ranged from 80-130 mm in size. Figures 4.1 and 4.2 show the mean, median, and range of coho smolt length and Fulton Condition Factor leaving John West Fork during the monitoring seasons 1998 through 2003.

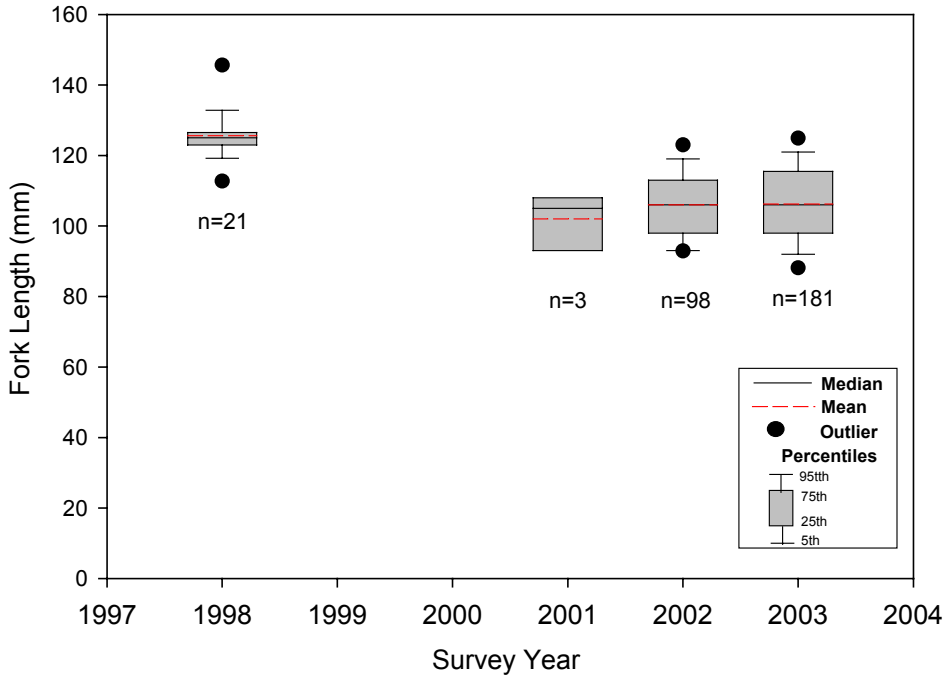

Figure 4.1. Coho smolt fork length box and whisker plots depicting mean, median, 5th, 25th, 75th and 95th percentiles, as well as outliers from John West Fork, Olema Creek during the monitoring seasons 1998 through 2003.

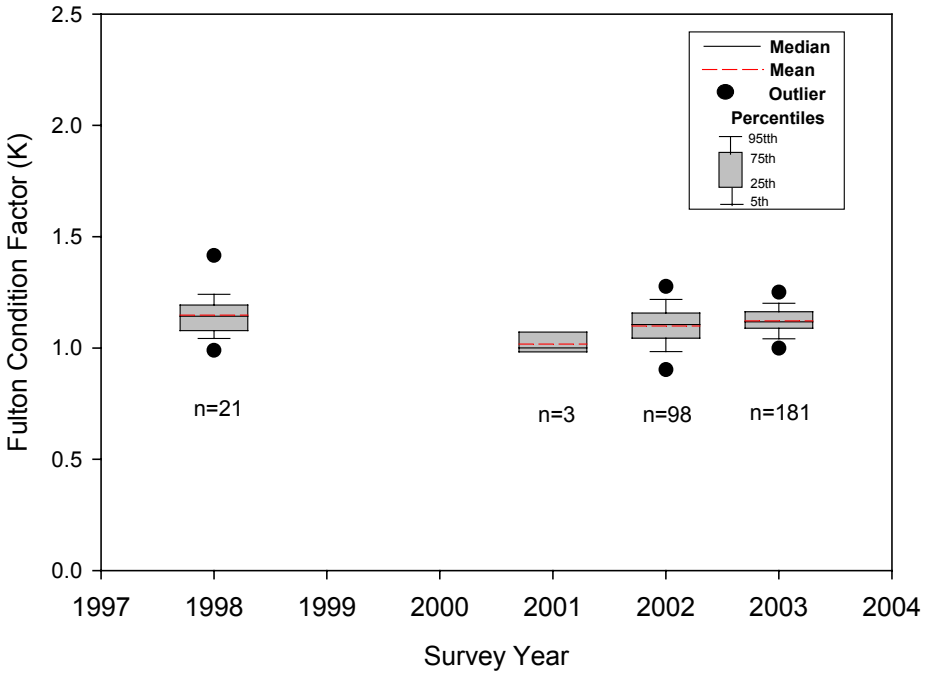

Figure 4.2. Coho smolt Fulton Condition Factor (K) box and whisker plots depicting mean, median, 5th, 25th, 75th and 95th percentiles, as well as outliers from John West Fork, Olema Creek during the monitoring seasons 1998 through 2003.

Despite the intermittent summer habitat conditions in the John West Fork, the size of coho observed emigrating through trap is not all that different from the smolts emigrating through the Pine Gulch Creek trap station. The John West Fork coho smolts were 1-2 grams heavier than the Pine Gulch Creek coho (Figure 4.3), although productivity is assumed to be higher in the perennial system. The greater variability of weight-length condition of the John West Fork coho smolts is indicative of the variable rearing conditions that occur in this intermittent tributary.

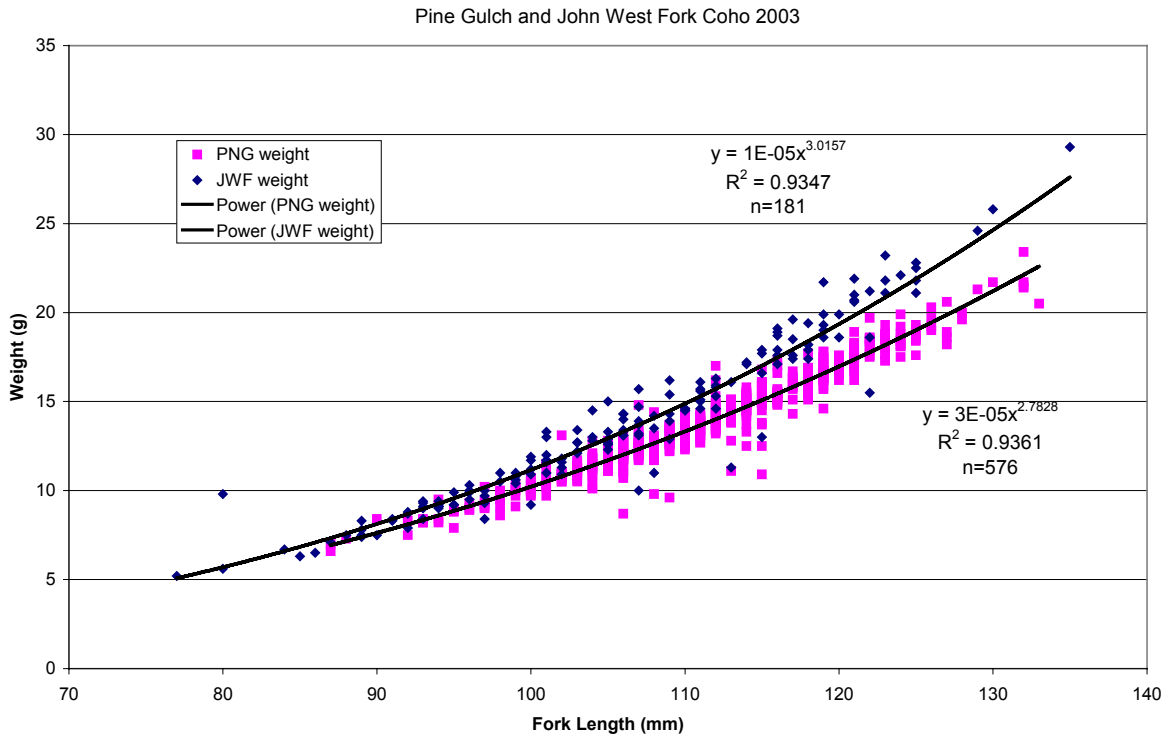

Figure 4.3 Comparison of coho smolt weight length relationships in Pine Gulch Creek and John West Fork of Olema Creek, Marin County, CA spring 2003.

6.0 TRIBUTARY SUMMER DENSITY MONITORING RESULTS

The summer monitoring efforts on Cheda Creek, John West Fork and Quarry Gulch were completed in June 2004.

6.1 Tributary summer monitoring methods

6.1.1 John West Fork

Three index reaches on the John West Fork have been monitored since 2000. As opposed to our findings on the mainstem, that index reach monitoring is representative of watershed response, the John West Fork index reach locations and results are highly linked to very localized observations specifically related to the culvert restoration. We have seen coho juvenile densities in excess of 9 fish per meter, which is linked to high redd densities observed the previous winter. Based on our findings tributary index reach surveys have been modified to cover a more representative part of the watershed, while still retaining elements related to the culvert restoration.

A habitat survey of the riparian protection area (1,200 meters) was surveyed identifying pool, riffle, and flatwater habitat. Two reaches, including the 200 meters below the culvert (Reach 1) and the 1000 meters upstream of the culvert and within the riparian protection area (Reach 2) were surveyed. Based on the habitat surveys, staff randomly selected three pool units in Reach 1 and four pool units in Reach 2 to sample. These sites were sampled in June.

6.1.2 Quarry Gulch

Three index reaches on Quarry Gulch have been monitored since 2000. These are confined to the lower areas west of State Route 1 and, while representative of a proposed habitat restoration area, are not developed to represent conditions (other than presence/absence of coho) in the tributary. Based on our findings tributary index reach surveys have been modified to cover a more representative part of the watershed, while still retaining elements related to the proposed restoration.

A full habitat survey of the reach downstream of State Route 1 was attempted. Because of large sections containing poison oak, some areas were avoided as part of the survey. Further confounding the efforts for a representative sampling of the tributary, electrofishing in one of the three randomly selected pools was abandoned due to the presence of a federally threatened California red-legged frog. This tributary has also been difficult to monitor in the past because of the poison oak and frogs. In addition, in 2001, staff identified CRLF tadpoles in the stream, the first documented reproduction in the area outside of pond habitat.

The limitations to the survey on quarry gulch are reflected in the presentation of information for this tributary.

6.1.3 Cheda Creek

Three index reaches on Cheda Creek have been monitored since 2001. These included a reach downstream of the fish passage restoration work area (2000), within the restoration area, and upstream of the area. While representative of a proposed habitat restoration area, are not developed to represent conditions (other than presence/absence of coho) in the tributary. Based on our findings tributary index reach surveys have been modified to cover a more representative part of the watershed, while still retaining elements related to the proposed restoration.

In Cheda Creek, two reaches, including the one kilometer reach downstream of theYear 2000 fish passage restoration site, and the intermittent or perennial reaches in the one kilometer reach upstream of the project site would be evaluated as separate reaches. In 2004, a habitat survey of the lower two kilometers of the stream channel was conducted in June to identify pool riffle, and flatwater habitat. Based on the survey, staff randomly selected two pool units to sample within each reach.

6.2 Tributary Monitoring Results

Results presented in this section are preliminary. Once all of the Coastal Marin salmonid monitoring is completed this summer analysis of data using statistical methods to develop confidence intervals around the reported information, habitat survey information, as well as fish measurement and condition information will be available.

6.2.1 John West Fork

In the John West Fork, a total of seven pool units were sampled within the two survey reaches. Habitat unit numbers were identified specific to each reach. In the reach downstream of the culvert (adult fish passage restored in 2000), electrofishing activities revealed the presence of steelhead (young of year and 1+), coho young of year (YOY), sculpin, and three-spined stickleback. In Reach 2, upstream of the culvert, the survey identified the presence of only coho YOY and steelhead YOY and 1+. This is indicative of the effect of the culvert, and likely historic drying of the tributary (possibly during the late-1970s drought). The culvert, despite restoration work to accommodate adult passage, likely remains a barrier to juvenile salmonids and other fish species in the watershed (Taylor and Associates 2003).

Density information is reported for each pool, based upon population estimates calculated using *Microfish* (VanDeventer and Platts 1989), and habitat surveys conducted in the field by staff. No attempt is made to estimate population or link the results between the randomly selected pools at this time. These data are presented as preliminary and are considered subject to revision.

Table 6.1 John West Fork Habitat Sample Results - June 2004

Reach 1	Unit 8			Unit 17			Unit 30					
	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+			
Habitat Population estimate	24	12	1	53	20	1	18	6	2			
Standard Error	.212	.312	-	7.414	1.058	-	0.809	1.381	0.384			
Fish per meter	3.20	1.60	0.13	4.91	1.85	0.09	4.74	1.58	0.53			
Fish per square meter	1.23	0.62	0.05	1.89	0.71	0.04	1.39	0.46	0.15			
Reach 2	**Unit 16**			**Unit 35**			**Unit 54**			**Unit 62**		
	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+
Habitat Population estimate	88	131	2	15	14	0	92	68	5	49	78	0
Standard Error	3.921	2.516	-	-	0.286	-	2.746	10.64	0.529	1.937	2.916	-
Fish per meter	5.21	7.75	0.12	2.42	2.26	-	8.07	5.96	0.44	5.05	8.04	-
Fish per square meter	1.80	2.67	0.04	1.50	1.40	-	4.80	3.55	0.26	3.37	5.36	-

6.2.2 Quarry Gulch

Quarry Gulch surveys were limited by the confounding factors including poison oak and California red-legged frog. Surveys of two pool units were completed within the tributary. Within these pools, coho YOY, Steelhead (YOY and 1+), sculpin, and three-spined stickleback were documented.

Density information is reported for each pool, based upon population estimates calculated using *Microfish* (VanDeventer and Platts 1989), and habitat surveys conducted in the field by staff. No attempt is made to estimate population or link the results between the randomly selected pools at this time. These data are presented as preliminary and are considered subject to revision.

Table 6.2 Quarry Gulch Habitat Sample Results - June 2004

Reach 1	Unit 6			Unit 3-1		
	Coho	SH YOY	SH 1+	Coho	SH YOY	SH 1+
Habitat Population	18	3	0	21	1	0

estimate						
Standard Error	1.133	0.745	-	0.742	-	-
Fish per meter	2.31	0.38	-	1.62	0.08	-
Fish per square meter	2.28	0.38	-	1.02	0.05	-

6.2.2 Cheda Creek

Cheda Creek, tributary to Lagunitas Creek was surveyed in June 2004, with unit numbers identified for each Reach. The two survey reaches are bounded by the fish passage restoration project site installed in 2000. The intent of the restoration activity was to remove a dam and restore adult fish passage through the area. Monitoring since 2001 had documented coho and steelhead in the index reach downstream of the project area, but only steelhead upstream. In 2004, one coho young of year was identified in the channel upstream of the fish passage restoration. This most likely implies that successful spawning of coho occurred upstream of the restoration site.

Two habitat units were surveyed in Reaches 1 and 2. In Reach 1, in addition to coho and steelhead, sculpin, roach, crayfish, and three-spined stickleback were observed. In Reach 2, only salmonids (primarily steelhead) were documented using the summer habitat.

Density information is reported for each pool, based upon population estimates calculated using *Microfish* (VanDeventer and Platts 1989), and habitat surveys conducted in the field by staff. No attempt is made to estimate population or link the results between the randomly selected pools at this time. These data are presented as preliminary and are considered subject to revision.

Table 6.3 Cheda Creek Habitat Sample Results - June 2004

Reach 1	**Unit 29**			**Unit 79**		
	Coho	**SH YOY**	**SH 1+**	**Coho**	**SH YOY**	**SH 1+**
Habitat Population estimate	18	22	2	19	25	0
Standard Error	1.133	0.722	-	-	0.431	-
Fish per meter	1.02	1.25	0.11	2.71	3.57	-
Fish per square meter	0.33	0.40	0.04	1.48	1.95	-
Reach 2	**Unit 116**			**Unit 31**		
	Coho	**SH YOY**	**SH 1+**	**Coho**	**SH YOY**	**SH 1+**
Habitat Population estimate	1	110	23	0	20	6
Standard Error	-	35.36	.452	-	2.171	0.471
Fish per meter	0.07	7.53	1.56	-	3.54	1.06
Fish per square meter	0.03	3.22	0.67	-	1.76	0.52

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